VII.—North American Ophiuroidea. I.—Revision of certain Families and Genera of West Indian Ophiurans. II.—A Faunal Catalogue of the known Species of West Indian Ophiurans. By A. E. Verrill.

Part I. Revision of certain Families and Genera of West Indian Ophiurans.

The numerous shallow water Ophiurans of the West Indian faunal region have been pretty fully studied by several authors,* so that most of the species are fairly well known, and many of them are to be found in most of the larger museums. Nevertheless there is no recent or fairly complete faunal list of the species.

The deep-sea species are also very numerous. These have been collected in large numbers by scientific explorations carried on by the U. S. Coast Survey Steamer "Blake," under the supervision of Mr. Alexander Agassiz, and by earlier explorations, under the supervision of Mr. L. F. de Pourtales. A number of deep-sea species were also dredged, in the same region, by the "Challenger." All the U. S. Coast Survey collections and those made by the "Challenger" were worked up and reported upon by Mr. Theodore Lyman in a number of important reports.†

The large collections from this region made by the U. S. Fish Commission steamer "Albatross" were also studied by Mr. Lyman, but no report upon them has yet been published.

During the present year the writer has published a report‡ on a small but interesting collection obtained by a scientific expedition to

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*Lütken, Addit. ad Hist. Ophiur., Part II; Synop. gen. Ophiur. ver.. 1869.

Lyman, North Amer. Ophiuridæ, Ill. Catal. Mus. Comp. Zool., I. 1865.

Ljungman, Ophiuroidea viv. hucusque cognita enumerat, Ofvers. Kgl. Vetenskaps-Akad. Forhandlingar, for 1866, 1867.

†Bulletin of the Mus. Comp. Zoology, Vol. I, No. 10, p. 309, 1869; Vol. V, No. 9, p. 217, 1878; Vol. X, No. 6, 1883; also Vol. V, No. 7, p. 67, 1878, and Vol. VI, No. 2, 1879 (Challenger Coll.).

Illust. Catal. Mus. Comp. Zool., Vol. VI, 1871; Vol. VIII, No. II, 1875.

‡Report on the Ophiuroidea collected by the Bahama Exped., 1893, Nat. Hist. Bulletin, Univ. of Iowa, Vol. V, pp. 1–86, Plates i–viii, 1899.

the Bahamas and Cuba from the University of Iowa, under the direction of Prof. C. C. Nutting. This collection included only such species as were obtained in less that 260 fathoms.

The present revision and list is based on several collections that I have studied, but mainly on the following :

I.—The general collections of the Peabody Museum of Yale University, in which is included a series of authentically named West Indian species, sent by Dr. Chr. Lütken, from the Museum of Copenhagen, many years ago.

II.—A pretty full series of deep-sea species dredged by the "Blake" and named by Mr. Lyman, sent by the Museum of Comp. Zoology.

III.—The collection made by the Bahama Expedition from the University of Iowa, referred to above.

IV.—The extensive collection made by the U. S. Fish Commission steamers "Albatross," "Fishhawk," and others, under my own supervision, in every year from 1871 to 1887, along the American coast north of Cape Hatteras, and including many deep sea species.

Only a small proportion of those in this last named collection appear to reach the West Indian faunal area, and therefore only a few of the species will be mentioned in this article. A special article on the Ophiurans of the north-eastern coast is, however, well advanced towards completion and will be well illustrated.

In the first part of this paper, I have endeavored to revise some of the larger and more difficult genera and families, and to supply analytical tables, so as to enable students of this group to identify the species without expending such a great amount of time as has been necessary hitherto. The Amphiuridæ and Ophiacanthidæ have, therefore, received here more attention than other groups, for they are always the most difficult to deal with.

In this article I have generally used the same names for the organs and parts that were used by Mr. Lyman in his various works on this group, but have made a few changes. I have preferred to use *oral shield* instead of "mouth-shield," *adoral shield* instead of "side-mouth-shield," and *oral papillæ*, in place of "mouth-papillæ." In the genera allied to *Amphiura*, I have usually called the "outer mouth-papillæ" or papillæ of the second oral tentacle, the *distal oral tentacle-scales* to indicate their homology with the ordinary tentacle-scales. The same idea has been carried out in *Ophiacanthidæ*. In the latter group I have designated the apical "mouth-papillæ" as *tooth-papillæ*.

Class OPHIUROIDEA.

Order I. **OPHIURÆ** Müller & Troschel, 1842.

Ophiuræ Ljungman, Oph. Viv., p. 303, 1867. Verrill, 1899*a*, p. 4.
Ophiuridæ Lyman, and many other authors.
Zygophiuræ and *Streptophiuræ* Bell, 1892.

Family, **PECTINURIDÆ** Verrill, 1899.

Ophiodermatidæ Ljung., Oph. Viv., p. 87, 1867. Lutk., Addit. Hist. Oph., iii, p. 87, 1869.
Pectinuridæ Verrill, Nat. Hist. Bull. Univ. of Iowa, v, p. 4, 1899*a*.

The generic name, *Ophioderma*, is now recognized only as a synonym of *Ophiura*. Therefore I have changed the name of this family, as is customary in such cases. The name *Ophiuridæ* cannot properly be used for the family group here included, because Mr. Lyman and many others have always used it to designate the order *Ophiuræ*, or all the *Ophiuroidea* exclusive of the *Euryalæ*.

Family, **OPHIOLEPIDÆ** Ljung., 1866.

Ophiozona nivea Lyman.

Ophiozona nivea Lyman, Illust. Catal. Mus. Comp. Zool., vol. viii, p. 8, figs. 85-86, 1875; Bull. Mus. Comp. Zool., vol. v, p. 128, 221; Three Cruises of the Blake, ii, p. 110, fig. 390, 1888.
Ophiozona nivea, var. compta Verrill, Nat. Hist. Bull., v, p. 9, pl. iii, fig. 2, 1899.

Variety, **compta** Verrill.

Plate XLIII. Figures 1, 1*a*.

The varietal name was given to the variety with distinctly separated radial shields, regardless of the variations in the oral shields, which happen to be, in both the specimens figured (pl. xliii, figs. 1 and 1*a*) of the shorter and more ovate form.

A study of a series of specimens sent to me by Mr. Lyman (from sta. 291, 200 fath., Blake Exp.) shows considerable variation in the form of the oral shields. These are sometimes oblong, twice as long as broad, with the outer and inner portions of the same width; in other cases the outer part, beyond the lateral indentations caused by the end of the genital slit, is broader than the inner part; in other specimens the outer part is narrower than the inner. The

number and arrangement of the large angular plates outside the oral shields are variable even on the same specimen. Usually there are three or four of the larger plates, of which two stand side by side, near the margin of the disk.

The radial shields are often separated distally by a row of two or three small angular plates and a large proximal plate as in our figure (pl. XLIII, fig. 1), but in other specimens the radial shields are in contact distally, but separated proximally by a single large triangular plate, as in Mr. Lyman's type-specimen of *O. nivea.* The central disk-plate is usually closely surrounded by five large angular plates, but in many cases there are small plates intervening more or less irregularly. The variations in the scaling of the disk and in the radial shields are not coincident with the variations of the oral shields.

This species is allied to *O. tessellata.* It is easily distinguished by the large, irregular disk-plates, wide, oblong, oral shields ; three subequal arm-spines, low down on the sides. There are no marginal spinules outside the radial shields. The upper arm-plates also differ in form.

Off Havana, 110 to 263 fathoms (Bahama Exped.). Taken by the Blake Exped. in 56 to 424 fathoms; off Barbadoes, 200 fath. (Blake Exped.).

Family, **OPHIOTHRICHIDÆ** Ljung.

Ophiothricidæ Ljung., Oph. Viv., 1866.
Ophiothrichidæ Lütken, Addit., iii, 1869. Verrill, Bahama Exped., p. 18, 1899.
Ophiothrichinæ Ljung., Joseph. Exp., 1871.

The family is characterized by the well defined group of true tooth-papillæ ; by the absence of oral papillæ ; by the usually numerous, long, slender, generally rough and glassy arm-spines; and internally by the complex, interlocking articulations of the arm-bones, and the strong mouth-frames and large radial shields. The peristomial plates, in the typical genera, are in three parts ; of these the middle one is large, like an oral shield. The dental plate or apical jaw-plate is a separate piece.

This family, as now limited, includes the following genera: *Ophiothrix, Ophiothela, Ophiocnemis, Ophiopsammium, Ophiomaza, Ophiogymna, Ophiocampsis* Duncan, *Ophiotrichoides* Ludw., *Ophiopteron* Ludw., *Lutkenia* Brock, *Gymnolophus* Brock, *Ophioœthiops* Brock, *Ophiosphærea* Brock, and *Ophiolophus* M. Tanner.

The more typical of these genera have the disk-scales covered with slender rough spinules, but the number and length of the spinules may vary considerably, even in the same species of *Ophiothrix*. Some of the genera have only granules on the disk-scales, and others have naked scales, and some even smooth skin.

Nearly all the genera and species of this family live clinging closely to various sponges, gorgonian corals, crinoids, hydroids, or even to other ophiuroids. Many of them are more active in their movements than is usual among *Ophiuroidea*, and many are bright colored when living.

The genus *Ophiopteron* Ludw. is very remarkable for having a broad membranous web between the arm-spines, and is supposed to be a free-swimming form. It is from Amboina.

The species of this family are mostly found in the warmer seas and in shallow water, and they are most abundant and most diversified in the East Indies. Brock enumerated fifty-six species of this family from the Indo-Pacific region and considerable additions have been made to the list by later writers. Several of the genera are known only from the East Indies or Australia. *Ophiothrix* is the only West Indian genus.

Family, **AMPHIURIDÆ** Ljung., 1867 (emended).

Amphiuridæ Verrill, Oph. Bahama Exp., Nat. Hist. Bull. Univ. of Iowa, v, p. 23, 1899.

In the report on the *Ophiuroidea* of the voyage of the Challenger, Mr. Lyman, 1882, recognized about ninety species of *Amphiura*. In subsequent papers by him and others, about thirty additional species have been described. This very extensive assemblage of species is evidently capable of being divided into several natural groups, in addition to the several minor groups already separated by Mr. Lyman and others. Mr. Ljungman, as long ago as 1867, set off a large number of species as a natural generic group, under the name of *Amphipholis*. At a still earlier date, Lütken had indicated this and other natural sections of the genus, without naming them.

Mr. Lyman, however, did not recognize *Amphipholis* and some other good divisions in any of his works, except as sections of the genus.

The contrast between the structure of the mouth in typical *Amphipholis* and typical *Amphiura* is very striking. The oral papillæ in the former can close up the mouth-slits tightly, acting like oper-

cula; while in the latter the few slender and widely separated mouth-papillæ cannot close the slits, but always leave them widely open. This difference is doubtless directly correlated with important differences in their mode of feeding and nature of their food.

Subdivisions of Amphiura.

The species of *Amphiura*, as adopted by Lyman, mostly fall into four large groups, which seem to be natural divisions of generic value. They are best characterized by the structure, number and arrangement of the mouth parts, as in most other ophiuran families. A few aberrant species, not found in American waters, must be referred to additional groups (V, VI, etc.).

I. *Amphiura* (restricted). Type, *A. Chiajei* Forbes.

One apical or subapical oral papilla. One (rarely two) small, distal papilla (oral tentacle-scale); middle of jaw-edge without papillæ; mouth-slits gaping. Four to seven or more (rarely three) arm-spines. Radial shields divergent.

II. *Amphipholis* (restricted). Type, *A. squamata* (or *A. elegans.*)

Two small lateral oral papillæ and one broad, operculiform, distal one, forming a continuous series along the entire jaw, and capable of nearly or quite closing the mouth-slits. Radial shields in close contact.

III. *Amphiodia* Verrill, 1899*a*. Type, *A. pulchella* (Lym.).

Three (rarely four) small subequal oral papillæ, none of them operculiform; they form a regular series, attached mostly to the side jaw-plate. No distal oral tentacle-scales. Three (rarely four) arm-spines. Radial shields often more or less joined.

IV. *Amphioplus* Verrill, 1899*a*. Type, *A. tumida* (Lym.).

Four or five small unequal oral papillæ, none operculiform, usually arranged in a discontinuous series, of which the outermost, at least, arises from the adoral shield and is really a distal oral tentacle-scale. Arm-spines three (rarely four). Radial shields generally quite separated. Disk scales naked.

V. *Paramphiura* Kœhl. Kœhler has recently established a new genus, *Paramphiura*, for *A. punctata* Forbes and *A. bellis*, var. *tritonis* Hoyle.

It is distinguished by having a pair of large supplementary scales or plates, proximal to the adoral plates. There are two small oral papillæ.

VI. *Ctenamphiura* Ver., gen. nov. Another special group is represented by *A. maxima* Lym.

It has three oral papillæ in a series, of which the middle one is very large and flat, and the outer one small and spiniform; the apical one is large. The mouth-shield is so large that it touches the first side-arm plate on each side, while the adoral shields are very small, not meeting within and not embracing the sides of the mouth-shield, as they do in all the other divisions of *Amphiura*. Two large tentacle-scales. Arm-spines very numerous, ten in the type. Upper and under arm-plates in contact. Disk scales coarse in the type. Radial shields separated.

The type, *C. maxima* (Lym.), is from the E. Indies in 28 fath.

Amphiura Forbes (restricted sense).

Amphiura Forbes, Trans. Linn. Soc., Vol. xix, pp. 149, 150, 1842 (type *A. Chiajei*). Ljungman, Ophiur. Viv., p. 318, 1867.

Amphiura (section B.) Lutken, Addit. Hist. Oph., ii, p. 114, 1859.

Amphiura (*pars*) Lyman, Bull. Mus. Comp. Zool., i, pp. 335, 338; Voy. Challenger, v, pp. 122, 124, 1882.

Amphiura (restr.) Verrill, Ophiur. Bahama Exped., v, p. 24, 1897.

Only one pair of true oral papillæ to each mouth-slit; they are placed on each side of the apex of the jaw. A single, usually spiniform, papilla, sometimes with a smaller one by its outer side, is situated on each side of the distal end of the mouth-slit, usually attached to the edge of the adoral shield. This is really the outer oral tentacle-scale.

Owing to the small number of oral papillæ and their peculiar arrangement, the mouth slits cannot be closed, but appear always gaping, more or less.

The edge of the jaw-plate, along its middle portion, is naked. Higher up in the mouth-slit there is a small spiniform papilla, usually visible from below; this is the tentacle-scale of the first oral tentacle. It is often shown in published figures as if it were a true oral papilla. Tentacle-scales usually one or two, sometimes lacking (section *Ophiopelte*).

Arm-spines short, usually four to seven or more, rarely three. Radial shields naked, small, generally divergent, with the distal ends either in contact or somewhat separated by small scales. The disk is usually covered with small naked scales.

In one group the under side is without scales (*Hemilepis*).

In a group referred by Lyman to *Ophiocnida*, the disk is covered with small spinules, but as the mouth-parts and other organs agree with typical *Amphiura*, it might better be regarded as a distinct genus, or else as a subgenus of *Amphiura*. To this I have given the name *Amphiocnida*. (See p. 316.)

The genus *Amphiura*, as here adopted, agrees nearly with the typical genus, as restricted by Ljungman in 1867. Mr. Lyman also stated that this should be the typical group, in case the genus were to be divided. This restricted genus still includes over sixty species, with a considerable diversity of structure, as the following table will show. The species are found in all seas and at all depths.

The arms are generally long and slender, tapering very gradually, and very flexible.

Many of the species, perhaps nearly all, live buried in the mud and sand of the bottom, or concealed in crevices or under stones, etc. When buried in the mud they usually project the tip of one or more of the arms above the surface of the mud.

This habit of living concealed is doubtless correlated with the absence of disk-spines for protection, and with the lack of special imitative colors.

Many of the species have plain, dull colors, resembling the color of the sea-bottom where they live. *A. Otteri*, from deep water, is plain salmon or light orange. Such colors are protective in deep water.

*Amphiura (restricted): Table of the species inhabiting the West Indies and adjacent waters, and the Atlantic Coast of North America.**

The characters given in this table are those of the *adult* specimens, or at least of the largest described and figured. The young specimens often have fewer arm-spines and differ in other particulars. The number of arm spines given is that of the fully developed joints, towards the base of the arms. The number of spines is also liable to vary in adult specimens. Characters not named in the table, such as the shape of the oral shields, radial shields, arm-plates, etc. are often of more value in determining the species than some of the characters mentioned, and should always be considered. They are not all easily utilized in a condensed table like this.

I.—Disk covered with naked scales.

A.—Tentacle-scales present. Radial shields divergent, their distal ends separated, or scarcely touching.

B.—Tentacle-scales two to a pore.

*In the table, the species that are entirely northern in their distribution are designated by an asterisk.

a.—Disk covered with scales above and below.

b.—Disk-scales thin and nearly even.

c.—Outer oral papilla flat or squamiform, usually with a small supplementary papilla by its side. Arm-spines 3 to 5, short and stout.

A. incisa Lym., '83. Arm-spines 3 ; radial shields wide. Disk-scales large.

A. Eugeniæ Ljung., '66. Arm-spines 4 or 5. Brazil.

cc.—Outer oral papilla spiniform, prominent.

d.—Arm-spines slender, tapered. Radial shield wedge-shaped, divergent.

e.—Arm-spines 4 or 5 ; lowest one longest, bent. Disk-scales minute.

A. complanata Ljung., '66. Brazil.

ee.—Arm-spines 6 to 8, nearly equal, two or three lower ones usually bent. Disk scales not minute, regular.

A. Otteri Ljung., '66. Maine to W. Indies, Portugal.

dd.—Arm-spines 5, short and stout, beaked. Disk-scales minute, obscure beneath. Radial shields narrow, touching distally.

A. Palmeri Lym., '82. West Indies.

bb.—Disk-scales irregular and swollen. Arm-spines 8. Outer mouth-papilla spiniform.

A. crassipes Ljung., '66. Brazil.

aa.—Disk naked beneath, or with rudimentary scales only. Radial shields narrow, elongated. *Hemilepis* Ljung., '71.

f.—Arm-spines 4 or 5, stout, subequal.

A. semiermis Lym., '69. W. Indies.

ff.—Arm-spines 6, tapered, lowest longest.

A. flexuosa Ljung., '66. Brazil.

BB.—Tentacle-scale only one to each pore. Arm-spines 3 to 6. Radial shields divergent, the distal ends sometimes touching, usually subovate or "pear-seed shape." A small supplementary papilla or "oral scale" often stands by the side of the outer oral papilla or oral scale.

g.—Oral shield transversely elliptical, rhombic, or quadrant-shaped, broader than long.

h.—Arm-spines 5 or 6, unequal, the lowest longest. Disk-scales minute, not in a rosette. Tentacle scale large, ovate. Oral shield elliptical. A supplementary oral scale is often present.

A. grandisquama Lym., '69. W. Indies.

hh.—Arm-spines 3, equal or subequal, tapered. Disk-scales not minute, forming a rosette. Tentacle scale small, flat. Oral shield quadrant-shaped. A supplementary oral scale is often present. Radial shields broad, in contact distally.

A. lunaris Lym., '78. W. Indies.

gg.—Oral shields longer than broad, oblong or ovate. Tentacle-scale minute. Arm-spines 3 to 5, short, subequal. Radial shields small, divergent.

i.—Disk-scales not minute, unequal, with edges rounded and serrulate, forming a rosette, oral shield small, subovate. Under arm-plates wide shield-shaped, little longer than broad.

* *A. Sundevalli* M. and Tr. Gulf of St. Lawrence.

ii.—Disk-scales minute, oral shields rather large, ovate. Under arm-plates oblong, much longer than broad.

A. Stimpsoni Ltk., '59. W. Indies.

AA.—Tentacle-scales absent or rudimentary.

j.—Disk destitute of scales below, or only partly covered. Radial shields divergent, pear-seed-shaped or wedge-shaped. = *Ophiopelte* Sars, Ljung.

k.—Arm-spines six or seven, short, straight. Disk-scales minute, not in a rosette.

l.—Arm-spines seven, lowest short and stout, others flattened, subequal. A supplementary outer oral scale. Oral shield obtusely angulated or convex distally and proximally. Dorsal arm-plates triangular, with the distal end very convex; five middle spines flattened and denticulated.

* *A. denticulata* Kœhl., '96. Off Newfoundland.

ll.—Arm-spines six, short. Oral shield acute-angled at both ends. Dorsal arm-plates broad, ovate.

A. Atlantica Ljung., '66. Off St. Helena.

kk.—Arm-spines three to five, slender, straight. Radial shields divergent.

m.—Arm-spines four or five, short. A rudimentary tentacle-scale sometimes present, usually wanting.

**A. fragilis* Verrill, '85. Arm-spines four or five, subequal, tips rough. U. S. East Coast.

mm.—Arm-spines three or four, equal, slender, straight. Radial shields small, touching distally, little divergent. Disk scales small, in rosette. Disk partly naked below.

* *A. exigua* Verrill, sp. nov. Gulf of St. Lawrence.

jj.—Disk entirely covered with scales below. Radial shields stout, largely joined, not divergent. Arm-spines three or four, equal, straight. Disk-scales rather coarse.

* *A. Canadensis* Verrill, sp. nov. Gulf of St. Lawrence.

II.—*Amphiocnida, gen or sub-gen. nov.* (see page 316).

Disk-scales bear small acute spinules. Arm-spines five to ten. Tentacle-scale usually absent. (No American species known.)

AMPHIPHOLIS Ljung. (restr.)

Type, *A. Januarii* Ljung.

Amphipholis Ljung., Ofvers. Kongl. Vet. Akad. Förhandl., p. 165, 1866; op. cit., p. 311; op. cit., p. 644, 1871.

Amphiura (*pars*) Lyman, Illust. Cat. Mus. Comp. Zool., i, p. 115, 1865; Bull. Mus. Comp. Zool., i, pp. 335, 339, 1869; Voy. Chall., v., pp. 122, 125, 1882.

Amphipholis (restr.) Ver., Oph. Bahama Exped., v, p. 24, 1899.

Three or four oral papillæ form a continuous series along the whole edge of the jaw; of these the distal one is attached more or less to the adoral shield and is operculiform or flat, and often much broader than the others. The two inner are usually small and conical. Disk generally covered with naked scales, but in one species bearing a few spines (Sec. AA). Radial shields naked and usually in close contact along the whole or most of their length. Arm-spines generally three (rarely four), small, slender, tapered. Tentacle-scales one or two, sometimes none.

In the more typical species the arms, though slender, are rather short and not very flexible, but in some others they are long, slender and very flexible.*

Table of the species of Amphipholis and Amphiodia from the West Indian region, including Brazil, and from the eastern coast of North America.

I.—*Amphipholis* Ljung.

Three (rarely four) oral papillæ; outer one operculiform or broad and flat, arising partly from the adoral shield. Radial shields joined.

A.—Disk covered with naked scales.

a.—Three arm-spines, rarely four, on basal joints.
b.—Arms of moderate length.

**A. elegans* (Leach) Ljng.	Europe, America.
A. tenera (Ltk.) Ljng.	W. Indies.
A. tenuispina Ljng.	N. Atlantic.
A. limbata (Grube) Ljng. Dorsal plates wide, short.	Brazil.
A. subtilis Ljng. Radial shields long and narrow.	Brazil.

bb.—Arms long and slender.

A. Goësi Ljng.	W. Indies.

aa.—Four or five arm-spines. Arms very long and slender. Radial shields long and narrow. Oral shields large, obovate. Adorals narrow. Outer oral papillæ very broad.

A. gracillima (Stimp.) Ljng.	S. Carolina.

AA.—Disk-scales with small, scattered spinules. Two small tentacle-scales. Radial shields in contact for half their length. Three arm-spines.

A. abnormis (Lym. '78, as *Ophiocnida*).	W. Indies.

* Among foreign species of this genus are the following: *A. squamata*, Europe; *A. Torelli*, Iceland; *A. Pugetana*, *A. violacea*, *A. microdiscus*, *A. Puntarenæ*, *A. geminata*, the last five from the west coast of America; *A. Patagonica*, Magellan Str.; *A. Koehii* (Lym.) and *A. Coreæ* (Duncan), East Asia. The following have four oral papillæ; *A. impressa* Lj., E. Indies; *A. depressa* Lj. and *A. hastata* Lj., from S. Africa.

II.—*Amphiodia* Verrill, 1899*a*. (See p. 316.)*

Oral papillæ three, rarely four, subequal, or the outer one is smallest, forming a regular series on the side of the jaw. Arm-spines three, rarely four. No distal oral tentacle-scale.

B.—Disk-scales naked.

c.—Two tentacle-scales.

d.—Radial shields rather wide, in contact at least distally.

A. Riisei (Ltk.) Ver. Oral shield elongate; adorals small, trigonal.

A. atra (Stimp.) Ver. Oral shield pelecoidal; adorals lunate, narrow. (Sometimes has four oral papillæ and four arm-spines.)

A. planispina (V. Mart.) Ver. Oral shield ovate, broadest proximally; adorals narrow, lunate. Brazil.

cc.—One tentacle-scale. Radial shields long and narrow, largely in contact.

e.—Disk with scales on the under side; on the upper side larger scales form a rosette. Arm-plates separated above and below. Oral shield obovate, smallest proximally. Adoral shield large, trigonal.

A. pulchella (Lym. '69) Ver. Florida.

ee.—Disk without scales below; no rosette above. Oral shield "spade-shape," with a distal lobe. Adoral shield broad triangular.

A. repens (Lym. '75) Ver. Florida.

BB.—Some of the disk-scales, near the margin or beneath, bear small spinules, or granules, or both.†

A. Lutkeni (Ljng.) Ver. West Indies.

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* *Amphiodia* is represented among extralimital species by a large series. Some are as follows. From west coast of America, five: *A. Barbarœ* (Lym.), *A. grisea* (Lj.), *A. urtica* (Lym.), *A. occidentalis* (Lym.), *A. Chilensis* (M. & Tr.), *A. Orstedii* (Ltk.), *A. antarctica* (Ljng.), Magellan Str.; *A. fissa* (Ltk.), Amoor; from the Indo-Pacific *A. ochroleuca* (Brock), *A. olivacea* (Brock), *A. impressa* (Ljng.), *A. Andreæ* (Ltk.), *A. lævis* (Lym.); from South Africa, *A. gibbosa* (Ljng.), *A. integra* (Ljng.)

† *Amphipholis Lutkeni* Ljng. and *Ophiocnida Loveni* (Ljng., Lym.) would, perhaps, go here, but they are so closely related to the type of *Ophiocnida* that I have referred to them under that genus (see p. 316).

Amphioplus, gen. nov. (See p. 306.)

Table of the species of Amphioplus from the West Indian region.

C.—Tentacle-scales present.

h.—Two tentacle-scales.

i.—Oral papillæ four to six, in a series; one or two are distal oral tentacle-scales. Arm-spines usually three, sometimes four.

j.—Dorsal and ventral arm-plates, at base of arms, in contact. Radial shields narrow, separated, or barely touching. Arm-spines three.

A. tumida (Lym. '78) Ver. Disk swollen ; radial shields linear. W. I., 321 fath.

**A. abdita* Verrill, '72. Radial shields lunate, parallel, middle arm-spine stouter, flattened, obtuse. Four oral papillæ. Long I. Sound.

**A. macilenta* Ver. Five oral papillæ. Spines all slender. East Coast U. S.

A. nereis (Lym. '83) Ver. Oral papillæ five, thick, unequal ; genital scale with a row of papillæ. W. I., 148 fath.

A. Agassizii Ver., p. 315. Oral papillæ six, slender, the two distal ones larger. W. I., 424 fath.

jj.—Dorsal arm-plates scarcely joined. Radial shields narrow and in contact distally. Five small, bead-like oral papillæ.

A. cuneata (Lym. '78) Ver. Three slender arm-spines. W. Indies.

ii.—Four (varying sometimes to three) oral papillæ. Arm-spines, three or four. Radial shields a little separated distally, divergent. Oral shield pelecoidal, acute proximally. Disk-scales do not form a rosette.

A. duplicata (Lym. '75) Ver. First under arm-plate often double; adoral shield narrow. W. Indies.

hh.—One tentacle-scale. Radial shields widely separated. Five unequal oral papillæ.

A. Stearnsi (Ives) Ver. W. Indies.

CC.—No tentacle-scale. Four oral papillæ. Four arm-spines. Radial shields touch distally.

A. Verrillii (Lym. '79) Ver. Radial shields rather large, divergent. Disk-scales form a rosette. W. Atlantic, 2650 fath.

Many extralimital species of *Amphioplus* have been described. Among them are the following :

A. canescens (Lym.) V., Pacific, 600 fath.; *A. glauca* (Lym.) V., Pacific, 345–420 fath.; *A. cernua* (Lym.) V., Pacific, 2300 fath.; *A. patula* (Lym.) V., Antarctic, 1975 fath.; *A. dalea* (Lym.) V., S. Atlantic, 2650 fath.; *A. lævis* (Lym.) V., Philippines.

Amphioplus Agassizii Ver., sp. nov.

Amphiura, sp., Lyman, Bull. Mus. Comp. Zool., vol. x, p. 253, pl. v, figs. 64–66, 1883.

Disk covered with minute scales, of nearly uniform size, not forming a central rosette. Radial shields narrow, separated by several rows of small scales. Oral shield obovate or pear-shape, evenly rounded distally, longer than broad, sides a little incurved. Adoral plate long, narrow, three-lobed, not meeting proximally. Oral papillæ six; of these the four inner ones are small, conical; the two outer are larger and broader and attached to the adoral plate.

Arm-spines three, slender, tapered. Tentacle-scales two, rounded. Under arm-plates are wider than long, broadly in contact and truncate at both ends. Upper arm-plates are broadly triangular, short, barely in contact.

This species, which was well figured by Mr. Lyman, but not named, is allied to *A. nereis*, but the latter has only five oral papillæ, of which four are stouter and blunter, while the outer one is minute; its oral shield is rounder; its under arm-plates are barely in contact, and have an inner angle; its arm-spines are larger and its disk-scales are also rather larger.

West Indies, 116 fath., Blake Exp.

Ophiocnida Lyman.

Subdivisions.

That this genus, as recognized by Mr. Lyman in his later works, is a heterogeneous group has been noticed by more than one writer. Mr. Lyman, himself, intimated as much in the Voyage of the Challenger. According to his view no difference exists between this genus and *Amphiura* except that *Ophiocnida* has spines or grains on the disk. But some of the species have only a few granules, while at least one species that he referred to *Amphiura* (*A. Lutkeni*) also has some small spinules on the disk, so that this distinction seems to be of little real value, taken by itself.* But as Mr. Lyman

* The same holds good in other cases. Thus *Ophiacantha* in some species has only granules, and *O. lævipellis* often has naked scales. (See p. 343.) In *Ophiothrix* similar variations are found.

included in *Amphiura* four groups that differ in their mouth-parts so widely that I have been led to separate them as genera, he naturally admitted the same variations in the mouth-parts of *Ophiocnida.* In fact we find in this group, as he finally left it, four divisions corresponding to the four divisions of *Amphiura* in structure of the mouth. They should be separated, therefore, if those of *Amphiura* are to be separated.

When originally constituted the genus included only two species. These are much alike and agree in mouth-parts. They have three subequal, true oral papillæ, arranged as in the division of *Amphiura* that I have called *Amphiodia*, to which they are in every way closely allied. It is, in fact, rather doubtful whether these two groups might not be united into a natural genus. In that case the variations in the covering of the disk might be considered as of merely sectional value.

But if we restrict *Ophiocnida* to the species having the characters of the types, they form a natural and easily recognizable group, which it is well, so far as known at present, to keep distinct. Mr. Ljungman gave the name *Ophiocnidella* to this typical group.

The second group, of which *O. Putnami* may be taken as the type, agrees with typical *Amphiura* in its mouth-parts, having but a single true oral-papilla, placed at the tip of the jaw, on each side, and one or two pairs of oral tentacle-scales at the distal corner. I have been inclined to consider this as a subgenus of *Amphiura*, for which I have proposed above (p. 307) the name *Amphiocnida.* It is, at any rate, very closely related to *Amphiura.* A study of its internal skeletal plates may hereafter show distinctions of more evident generic value.

The third group includes, so far as I know, only *O. abnormis* Lym. This agrees so completely in its mouth-parts, spines, etc. with typical *Amphipholis*, that I do not hesitate to unite it with that genus, considering the sparingly spinulose disk as merely of sectional value. (See p. 313.)

Another group, *Amphilimna*, having *O. olivacea* as its type, has more numerous oral papillæ and arm-spines, and a generally robust structure quite unlike the typical forms. Although corresponding with *Amphioplus* in the number of oral papillæ, this group seems to have special characters worthy of generic rank.

The following synopsis will give the principal characters of the three more important divisions discussed above, and of most of the described species :

Ophiocnida Lym., 1865 (restr.). Type *O. hispida* Lym., 1865.

Ophiocnida Lym., Ill. Catal. Mus. Comp. Zool., i, p. 133, 1865; *pars*, Voy. Challenger, p. 152, 1882.

Ophiocnidella Ljung., Ofv. Kongl. Vet. Akad. Förhandl., vi, 1871, p. 649 (Type *O. scabriuscula*).

Oral papillæ three, subequal, arranged in a series along the jaw-margin. Disk-scales distinct, bearing spinules or granules. Arm-spines three to five. Radial shields divergent. Two tentacle-scales; rarely one.

A.—Disk with numerous acute spinules.

a.—Arm-spines three, rarely four.

O. hispida (LeC.) Lym. '65. Spines three. Disk with many slender sharp spinules. Panama.

O. scabriuscula (Ltk.) Lym. '65. Spines three. Disk spinose. Disk-scales thick. Oral papillæ blunt, nearly equal. W. Indies.

O. echinata Lym. '74. Spines four. Disk very spinose. Adoral shields trigonal. Radial shields narrow. E. Indies.

O. sexradia Duncan. Six rays; four arm-spines; one tentacle-scale. E. Indies.

aa.—Arm-spines five or six.

O. scabra Lym. '79. Lowest spine thick and rough. Proximal oral papilla apical and bead-like. Adoral shield lunate. Off Bahia, 1275 fath.

AA.—Disk-scales partly bare; partly with granules or very short spinules, or both.

b.—Disk-scales large, in a rosette, mostly naked; some marginal and submarginal bear granules. Three arm-spines.

O. filogranea Lym. '75. Radial shields wide, divergent. Adorals lunate. Two tentacle-scales. Florida.

bb.—Disk-scales smaller, many naked; some marginal and submarginal bear grains or small conical spinules.

O. Loveni (Ljng.). Disk-scales in a rosette; some at margin, bear spinules; others below, bear granules. Outer oral papilla flat. Radial shields touch distally. Rarely four arm-spines. Brazil.

O. Lutkeni (Ljng. '71). A few submarginal and marginal scales bear small spinules. Three arm-spines. Dorsal arm-plates wide, usually broken into two or more parts. W. Indies.

Amphiocnida, gen. nov. = *Ophiocnida* (*pars*) Lym.

Disk-scales bear small acute spinules. Apical oral papilla small. Distal oral papilla (oral tentacle-scale) acute, spiniform. Middle of jaw-margin naked. Arm-spines five to ten. Typical species have no tentacle-scale.

A. Putnami (Lym.). Arm-spines nine to ten, stout, upper one clavate. Radial shields separate. No tentacle-scale. Hong Kong.

A. pilosa (Lym.). Arm-spines five to six, slender, tapered. Adoral shields trilobed. Radial shields, little separate. No tentacle-scale. Bass Straits.

A. alboviridis (Brock). Arm-spines five to six. No tentacle-scales. E. Indies.

A. brachiata (Mont.). Arm-spines seven to ten, flattened, one with an apical cross-piece. Europe.

Amphilimna Verrill. Type, *A. olivacea.*

Amphilimna Verrill, Ophiur. Bahama Exp., v, p. 30, 1899.

Oral papillæ four or five in a series. Tooth papillæ two to four. Arm-spines six to ten, of moderate length. Tentacle-scales usually two, spiniform, one each side of the tentacle-pore. Disk swollen dorsally, with a notch over the base of each arm, and covered with spinules. Radial shields parallel, largely in contact. This genus includes, besides the type, only *A. Caribea* Ljung.

Amphilimna olivacea Ver.

Ophiocnida olivacea Lyman, Bull. Mus. Comp. Zool., i, 10, p. 340, 1869; Ill. Cat. Mus. Comp. Zool., vi, pl. i, figs. 7, 8; Bull. Mus. Comp. Zool., v, 9, p. 227; op. cit., x, p. 253. Verrill, Amer. Jour. Sci., vol. xxiii, p. 219; Ann. Rep. U. S. Fish Com., vol. x, p. 661; op. cit., vol. xi, p. 549. Lyman, Report Voy. Challenger, Zool., *Ophiuroidea*, v, p. 156, 1882.
Amphilimna olivacea Ver., Ophiur. Bahama Exped., v, p. 30, 1899.

Plate XLII, Figures 1, 1*a*.

Arm-spines nine or ten; oral papillæ four or five.

Taken by the U. S. Fish Commission at numerous stations off the east coast of the United States, from off Martha's Vineyard to Cape Hatteras, in 63 to 192 fathoms, and by the "Blake" from off Rhode Island to the West Indies, in 40 to 126 fathoms. Off Key West, Florida, 75 to 80 fath. (Bahama Exp.).

A. Caribea (Ljung.) Ver.

Arm-spines six, rough. Oral papillæ four, the two distal ones squamiform.

It is possible that this species, from the West Indies, 300 to 400 fath., is the young of *A. olivacea*. In that case the latter name would become a synonym.

Family, **OPHIACANTHIDÆ** Ver.

Ophiacanthinæ (sub-family of *Amphiuridæ*) Ljungman, 1866; Lütken, 1869.
Ophiacanthidæ Verrill, Ophiur. Bahama Exped., Nat. Hist. Bulletin, v, p. 34, 1899.

The family is characterized by the prominent and highly developed side arm-plates, usually meeting above and below, and by the numerous, usually long, and more or less rough spines, which stand out nearly at right angles to the arm. The spines may be solid or hollow, glassy or opaque, terete or flat.

The oral papillæ are usually rather numerous and form a continuous row along the sides of the jaws, but the outer ones may be of larger size or different in form from the others, or clustered, and in such cases they are really the distal oral tentacle-scales. There may be only a single apical tooth-papilla, or there may be two or three, and sometimes there is a large cluster. The first under arm-plate is usually concave or somewhat bilobed within the mouth-slit, and usually bears two vertical flat processes, which sometimes become movable, like oral papillæ.

In some cases the outer oral tentacle-pore is exposed to view on the outer margin of the jaw, and then it has one, or sometimes several, special oral scales or papillæ by its outer side, or partly surrounding it. Some of its scales may be attached to the adoral plate, or even to the first under arm-plate. This plate is usually concave or somewhat bilobed, and usually bears two inner, lateral, scale-like processes, which are sometimes movable and papilliform like oral papillæ.

There is generally a single median acute tooth-papilla at the tip of the jaw, but there may be two or three, and in some cases (*Ophiocamax*, *Ophiomitra*, *Ophiotrema*) there may be a cluster of several spiniform tooth-papillæ. These were counted as oral papillæ by Mr. Lyman, but when they stand on the dental plate they should be considered as true tooth-papillæ.

The teeth are stout, flattened, obtuse; they vary from three to eight in number.

The internal structure of the mouth-parts and arms is much like that of some of the *Amphiuridæ*. The "jaw-plate" or dental plate is generally separate from the jaws, and the three parts of the peristomial plates are generally distinct, but they are united in *Ophiocamax*.

The genera *Ophioplax* and *Ophiolebes* are, in several characters, more or less intermediate between the two groups, both externally and internally.

This family, as here understood, includes the following genera: *Ophiacantha*, *Ophiomitra*, *Ophiotrema*, *Ophiocamax*, *Ophiolebes*, *Ophiothamnus*, *Ophiocopa*. *Ophiochiton*, *Ophiotoma*, and probably *Ophioblenna*. To these I have recently added several others, enumerated below, separated from *Ophiacantha*, *Ophiomitra*, and *Ophiopsila*.

The first six of those named above have the disk covered with scales bearing spinules or thorny processes, or sometimes granules. *Ophiochiton* and *Ophiocopa* have naked or nearly naked scales. *Ophioblenna* and *Ophiotoma* are covered with naked skin. The radial shields may be large or small, concealed or exposed.

Ophiacantha Müll. and Troschel, 1842. (*sens. ext.*)

The species of this genus, taken in the extended sense, are very numerous in all seas and are difficult to determine. They are abundant in deep water in northern latitudes, as well as in tropical seas. Ten or eleven species are known off the coasts of New England and Newfoundland. Several of them occur only at great depths. About twenty species, including two described as new in this article, are known from the West Indian fauna.

This genus is very remarkable for the great variations in the armature of the disk. Some species have only rounded granules; others well-formed tapered spines; others short, thorny stumps; others small bifid or trifid spinules or crotchets; while many species have mixtures of two or more of these sorts.

It is probable that these structures have been developed as protective organs, in accordance with the ordinary laws of Natural Selection, and that they are, therefore, directly correlated with the habits of the various species. But the habits of many species are not yet known. I have found several species clinging to gorgonian

corals, or lodged among their branches; others have occurred on hydroids; certain species, like *O. fraterna* and *O. bidentata*, often occur in vast numbers in the dredge where the bottom is composed of broken shells, covered with hydroids, sponges, crinoids, etc., among which they evidently find shelter; some species, as *O. gracilis* and *O. pentacrinus*, cling closely to crinoids.

It seems, therefore, that most of the species live more or less exposed to the attacks of fishes and other active enemies, against which a covering of sharp spines would afford some protection. But as fishes avoid coral-animals and hydroids, on account of their stinging powers, it might be expected that those species living among the branches of such organisms would require less protection by spines than those that merely conceal themselves, more or less, among the debris of the sea-bottom. A more careful study of the habits of the shallow-water species may determine, hereafter, whether such differences in habits have determined the evolution of the spines of the disk.

As for the long arm-spines, characteristic of most of the species of this and allied genera, they appear to have been developed in nearly all genera that habitually live exposed,* while those genera that live buried in the mud or sand, like *Ophioglypha*, *Ophiomusium*, *Amphiura*, *Amphipholis*, etc., or securely hidden in crevices or under stones, generally have short arm-spines.

Some of the species of *Ophiacantha* are brilliantly phosphorescent when first caught. I have myself observed this to be the case with *O. bidentata*, *O. fraterna*, and others. It may, very likely, be a peculiarity of the deep-water species, if not of all the others.

Owing to the difficulties in the way of the ready identification of the species, I have prepared the following analytical tables, which ought to aid materially in locating any of them, if the specimens be full grown, or nearly so. The young often differ considerably from the adults in the number and roughness of the arm-spines, armature of the disk, etc. The number of arm-spines counted is that of the largest groups, near the base of the arms; farther out the number rapidly decreases. The number of oral papillæ often varies with age, and also individually, in many species, especially in those in which they are numerous and clustered. The number of tentacle-scales,

* The genus *Ophiothrix* is notable for the high development of its spines. The species usually live more or less exposed, clinging to sponges, gorgonians, etc., which they often closely imitate in color, but some species live in the internal cavities of sponges.

or the number of joints that have two pairs varies in some species according to age, the number of these parts and of the spines increasing in the older specimens. In very large specimens of small species there is often a tendency to develop extra oral-papillæ and tooth-papillæ, either above or below the regular series. The precise number of species cannot be considered as constant in any species, and must always be understood to vary within more or less definite limits. This character has been used in some of the analytical tables only because of its easy observation. The degree to which the larger basal rows of spines approximate dorsally is of more importance, though not invariable, and the character of the serrulations or thorns on the spines is of considerable value, though slightly variable, even in adult specimens. The spines are always rougher in the young specimens.

Moreover, in using the analytical tables, it must be remembered that some of the species have been described only from a single specimen* and that the amount of variation is still unknown, in certain deep-sea species, which have not yet been studied from the later and larger collections.

It is also to be noted that in the case of deep-sea species, especially those obtained by the "tangles," many of the delicate parts are liable to be broken or torn off, and in the case of tentacle-scales and oral papillæ they may leave no traces. When such parts are reproduced they may not appear in the same number or form as at first.

Such accidents may account for many cases where the different arms or different jaws of a single specimen present variations in their appendages,† as well as for specimens in which all the arms

* Mr. Lyman's custom was to describe all his new species from a single type specimen. Had his health remained unimpaired he would, doubtless, have revised more fully the large collections from the later Blake Expeditions.

† In a large lot of typical *Ophiacantha bidentata* one abnormal specimen shows curious variations in the mouth-parts, which may be due to the repair of damages. The number of regular oral papillæ on the different jaws varies from three to five. On some jaws there is a rudimentary, wart-like, distal one; in others it is as large as the next; on one jaw there is an extra, slender, clavate papilla, back of the first, on the lower face of the jaw; the distal papilla is thick, blunt, clavate, and usually somewhat triquetral; one jaw has two papillæ grown together for half their length; one has an extra papilla above the inner one, and of the same form. The tooth-papillæ vary in form and size, and from one to three in number; one jaw has a terminal pair; and on one jaw some of the teeth are split into two. The first arm-plate has a vertical process on

vary. These ophiurans are able not only to reproduce a whole set of arms, but the entire upper part of the disk itself may be lost and reproduced.

As for the species included in the following tables, I have personally studied nearly all of them, and the few that I have not seen are well figured by Mr. Lyman.

Dichotomous analytical table of the East Coast and West Indian species that have been referred to Ophiacantha (sens. ext.)

In this table I have arranged the species as nearly as possible in accordance with what seems to be their natural relations.

Those prefixed by an asterisk (*) are from the American coast north of Cape Hatteras. All others are from the West Indian fauna.

A.—Oral shields join the first side arm-plates. Adoral shields are entirely proximal to the oral shields.

B.—True *Ophiacantha.* Disk wholly, and radial shields mostly, covered with small crotchets, thorny stumps, or short spinules or granules, or with a mixture of these forms.

C.—Disk covered with small crotchets, or short thorny stumps, or short spinules, with no elongated spines nor granules.

d.—Arm-spines finely serrulated, or nearly smooth under a simple lens, usually long and tapered, hollow, not glassy.

e.—Opposite basal rows of arm-spines, in the adults, are closely approximate dorsally or nearly so.

f.—Oral papillæ form a simple row, the distal one being generally the largest.

* *O. bidentata* (Retz.). Disk with short, thick, rough, obtuse stumps and crotchets. Distal oral papillæ wider, truncate. Tentacle-scale single, obtuse.

* *O. aculeata* Ver. Disk with slender, thorny, stumps. Distal oral papilla wide, flat, mucronate at the corner. Spines eight or nine, nearly smooth. Tentacle-scale lanceolate, acute. Arm-spines not always approximate dorsally.

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each side, not movable. The large outer tentacle-pore is visible from below, when the distal papilla is removed. The first oral tentacle is far up in the distal part of the slit and has no papillæ. The uppermost tooth is longer and more pointed than the rest. There may be two clavate tentacle-scales on the first joint.

* *O. fraterna* Ver. When full grown the arm-spines usually closely approximate dorsally (see p. 321).

* *O. abyssicola* Sars. Spines six, short, nearly smooth. Disk covered with fine crotchets.

* *O. anomala* Sars. Six arms. Oral shields narrow, or acute. Disk-spinules short, thick, conical or obtuse, roughly serrulate or thorny.

ff.—The distal oral papillæ, or oral tentacle-scales, are clustered or form a double row; all spiniform. Tentacle-scale spiniform.

* *O. enopla* Ver. Arm-spines seven or eight, roughly serrulate. Disk covered with small, short, obtuse stumps, having several terminal thorns.

ee.—Basal rows of spines not very closely approximate dorsally. Oral papillæ in a simple row.

* *O. fraterna* Ver. Disk covered with very small thorny spinules and crotchets and some rough granules. Oral papillæ three, acute, spiniform. Arm-spines eight, serrulate. Tentacle-scale small, flat, subacute. Arm-spines, in large specimens, are approximate dorsally.

O. cosmica Lym. Disk with coarse thorny stumps having several points at the end. Oral papillæ three, stout, conical. Tentacle pores large, with one large scale. Upper arm-plates slightly joined at base of arms.

dd.—Arm-spines decidedly thorny or prickly, and usually glassy, mostly long and slender.

g.—Basal rows of spines approximate dorsally. Side arm-plates very prominent. Disk with small, slender crotchets or branched spinules.

O. aspera Lym. Arm-spines nine or ten, slender, very thorny. Disk covered with fine thorny crotchets and stumps, terminated by two to six points. Tentacle scale single, flat, larger at the end, and thorny or lobed.

* *O. millespina* Ver. Arm-spines ten, long, roughly serrulate. Disk closely covered with small, thorny or branched spinules.

O. pentacrinus Ltk. Arm-spines six, upper ones very slender, not very thorny. Disk with fine crotchets. Tentacle-scale single, small, flat. Distal oral papilla flat.

O. scutata Lym. Arm-spines eight to ten, long, decidedly thorny. Basal tentacle-pores with two flat scales; one, and spiniform, farther out. Three tooth-papillæ. Disk-scales covered with small, thorny crotchets. A pair of papillæ on first under arm-plate.

gg.—Basal rows of spines not closely approximate dorsally. Disk with short thorny stumps.

O. stellata Lym. Arm-spines seven, very thorny. Three conical oral papillæ. One tooth-papilla.

CC.—Disk entirely covered with tapered spinules or true spines, or having more or less of them mixed with granules or other structures, or else covered with granules only.

h.—Disk covered with spinules only, or else having spinules mixed with other structures, not granulated.

i.—Disk with spinules only or mainly.

j.—Dorsal rows of spines approximate dorsally.

**O. spectabilis* Sars. Arm-spines six to eight, serrulate. Disk with tapered spines and some small conical stumps. Tooth-papillæ and distal oral papillæ clustered.

jj.—Basal rows of spines not approximate dorsally.

k.—Arm-spines finely serrulate, not glassy. Tooth-papilla single. Oral papillæ in a simple row.

O. segesta Lym. Arm-spines tapered, nearly smooth. Disk-spines small, slender, smooth, mixed with few crotchets and thorny stumps. Tentacle-scale single, small, acute. Oral papillæ three, conical, all similar.

* *O. crassidens* Ver. Arm-spines short, stout. Oral papillæ and teeth large and thick, rough. Disk with small, acute, conical spinules.

kk.—Arm-spines thorny and glassy. Disk-spines slender, thorny, acute; several tooth-papillæ.

O. pectinula Ver. Outer edge of dorsal arm-plates with a row of small acute serrations. Several distal oral papillæ.

ii.—Disk bearing few tapered spines mixed with other structures. Rows of spines approximate dorsally.

l.—Disk covered with granules mixed with a few tapered spines. Arm-spines finely serrulate or nearly smooth.

O. vepratica Lym. Arm-spines eight, long, tapered. Oral papillæ three, conical. Tentacle-scale single, large, conical or spiniform.

ll.—Disk-spines elongated, mixed with crotchets or thorny stumps. Arm-spines more or less finely serrulate.

O. varispina Ver. Arm-spines eight, serrulate, translucent. Disk with thorny stumps and few acute spines. Tentacle-scale single, flat, subspatulate. Oral papillæ wide, flat, obtuse; distally there is often an extra marginal one.

hh.—Disk covered with small close granules alone. Basal rows of spines not approximate dorsally. Arm-spines serrulate; under arm-plates short and broad, separated.

* *O. granulifera* Ver. Arm-spines nine, the upper ones long and slender, finely serrulate, lower ones short, rough. Oral papillæ all spiniform. Tentacle-scale lanceolate, two on first joints.

BB.—Radial shields largely uncovered. Disk-scales either partially naked and easily visible, but bearing more or less granules or spinules, or else entirely concealed.

m.—Disk-scales largely exposed.

n.—*Ophialcæa* Ver., 1899*a*, pp. 38, 42. Dorsal arm-plates largely in contact. Arm-spines nearly smooth, the rows widely separated dorsally.

O. Nuttingii Ver. Arm-spines four, short, tapered. Disk-scales small, exposed, bearing small spinules. Radial shields partly exposed, narrow, separated. Tentacle-scales single, large.

nn.—*Ophiomitrella* Ver., 1899*a*, pp. 39, 43. Dorsal arm-plates separated by the side-plates. Arm-spines slender, thorny; the basal rows approximate dorsally.

O. lævipellis (Lym.) Disk-scales small, sometimes entirely naked, sometimes with small scattered granules. Radial shields small, separate, partly naked. Tentacle-scale single, small, acute. A pair of papillæ on the first under arm-plate.

mm.—Disk-scales mostly concealed, but radial shields naked.

o.—*Ophiacanthella* Ver., 1899*a*, p. 39. Basal rows of spines not approximate dorsally. Dorsal arm-plates largely in contact. Radial shields long, mostly naked, in contact by their edges. Arm-spines nearly smooth. Three tooth-papillæ. Oral papillæ four, conical, all similar.

O. Troscheli (Lym.) Arm-spines six, tapered. Disk-scales concealed, bearing granules and scattered spines. Tentacle-scale single, lanceolate.

oo.—*Ophioscalus* Ver., 1899*a*, pp. 39, 42. Dorsal arm-plates separated. Basal rows of spines closely approximate dorsally. Radial shields large, broad, naked, in contact for their whole length. Two or three tooth-papillæ. Arm-spines thorny and glassy.

O. echinulata Lym. Disk-scales small, nearly concealed by numerous slender, thorny spines.

AA.—The oral shield is separated from the side arm-plates by the distal lobe of the elongated adoral shields, which are therefore, not entirely proximal to the oral shields.

D.—Adoral shields narrow, trilobed, the narrow distal lobe separating the oral shield from the side arm-plate. Disk-scales usually concealed by cuticle and spinules.

E.—*Ophiopora* Ver., 1899*a*, p. 43. No tentacle-scales, the pores are very large; spines small, usually smooth.

O. Bartletti (Lym.) Ver. One spiniform distal oral papilla by the side of the oral tentacle-pore. Disk covered with acute spinules.

EE.—One or two tentacle-scales.

p.—*Ophiolimna* Verrill, 1899*a*. Arm-spines seven or eight, nearly smooth, placed obliquely on the distal part of the plates, not strongly divaricate. Jaws more or less granulated. Disk-scales and radial shields concealed, bearing granules and spines.

**O. Bairdii* (Lym.) Ver. Upper arm-plates separated. Rows of spines approximate dorsally. Tentacle-scale single.

O. mixta (Lym.) Ver. Upper arm-plates joined. Rows of spines wide apart dorsally. Two flat tentacle-scales.

pp.—*Ophiopristis* Ver., 1899*a*. Arm-spines serrulate, not obliquely placed. Strongly divaricate. Dorsal arm-plates separated. Tooth-papillæ usually three.

q.—Spines partly flattened, serrulate on the edges. A row or cluster of several distal oral papillæ at the large oral tentacle-pore. Two tentacle-scales on the basal joints.

O. hirsuta (Lym.) Ver. Disk-spines slender, tapered, acute. Arm-spines five or six, strongly serrate on the edges. Three tooth-papillæ. Two flat tentacle-scales.

O. ensifera Ver. Disk-scales visible, bearing small conical spinules. Spines four, blunt, mostly flat. Two flat tentacle-scales on the basal joints.

O. cervicornis (Lym.) Ver. Disk with granules and small acute spinules. Tentacle-scales two, spiniform; pores very large, open. Arm-spines six, short, flat, serrate.

qq.—*Ophiotreta* Ver., 1899*a*, p. 40. Only one or two, rarely three, oral tentacle papillæ, which are flat. Two to four or more tooth-papillæ. Arm-spines terete or only a little flattened, slender, serrulate or nearly smooth.

O. lineolata (Lym.) Ver. Arm-spines six or seven, slender, nearly smooth. Tooth-papillæ three to five. Two unequal tentacle-scales on several basal joints. Disk evenly granulated, and with a few scattered spines. Jaws often bear granules.

O. sertata (Lym.) Ver. Tooth-papillæ two or three. Spines seven, finely serrulate, partly flattened.

DD.—*Ophiothamnus* Lym. Adoral shields large, wedge-shaped with the broad distal end separating the narrow ovate oral shield from the side arm-plate. Disk-scales exposed. Radial shields more or less naked, close together.

**O. gracilis* Ver. Arm-spines four or five, upper ones slender, lowest rough. Disk with truncate, thorny stumps. Tentacle-scale spiniform or palmate.

O. vicarius Lym. Disk-scales bear slender, tapered, acute spinules. Tentacle-scale small, conical.

O. exigua (Lym.)

Ophiacantha should be restricted and subdivided.

In this group the armature of the disk does not seem to be correlated with other important characters; neither does the number nor the length of the arm-spines, nor their solidity, or translucency, or hollowness, nor their degrees of roughness.

One of the characters that seems to be of much importance for the separation of the typical genus, from other allied generic groups,

hitherto confounded with it, is the nature of the adoral shields. In the typical group these are small and quite in front of the oral shields. In several other divisions they extend outward in a distal lobe that separates the oral shield from the side arm-plates, as in *Ophiocopa*, etc. (See group AA, p. 327, and group XIII, p. 340.)

Other characters of importance for the separation of groups of some value, are the presence of several tooth-papillæ at the apex of the jaw (groups B, C, G, K, pp. 330–333); the presence of a large submarginal oral tentacle-pore, with special papillæ around it, in a row or cluster (see group J, p. 333); the partial nakedness of the disk-scales and radial shields (group F, p. 332); the size and contiguity of the radial shields (group G, p. 332); the contiguity of the dorsal arm-plates (group G, p. 332); absence of tentacle-scales and the large size of part or all of the pores (group H, p. 333, and group E, p. 332).

Some of these characters, even those of most importance, have not been referred to in many of the published descriptions, nor represented in the figures. Therefore many of the species cannot, at present, be definitely classified. Mr. Lyman's figures, in the Voyage of the Challenger, are generally very accurate, but even some of these fail to show certain details of structure needful for accurate classification of the species of this genus.

Ophiomitra Lyman (typical group) differs but little from some sections of *Ophiacantha*. It has the tooth-papillæ and distal oral papillæ numerous and clustered, as in section C; the distal oral tentacle-pore is large and partly exposed, as in section J. The radial shields are large and nearly naked and the disk scales are visible and spinose. Several species referred to *Ophiacantha* by Lyman also have naked disk-scales and radial shields (groups F and B, *aa*).

Subdivisions of Ophiacantha.

From the preceding remarks and table, it will be plain that several genera and subgenera* may be separated from the old genus *Ophiacantha* with characters that appear to be of as great morphological value as those that characterize, for instance, *Ophiomitra* or *Ophiochiton*.

* Most of these subdivisions were proposed in the Report on the Ophiuroidea of the Bahama Exped., Nat. Hist. Bull., Univ. Iowa, v, 1899. (Designated as 1899*a* in this article.)

Series I.

Ophiacantha (restricted). Types, *O. setosa* and *O. bidentata.*

Group A.—Typical *Ophiacantha.*

Oral papillæ form a simple row. One median tooth-papilla at the tip of the jaw. No special oral tentacle-scales at the distal angles of the mouth-slits, though the outer papilla, which serves as a tentacle-scale, may be wider than the rest. Oral tentacle-pore not exposed outside of the jaw-margin. Disk-scales more or less obscured by integument and bearing spinules, thorny stumps, crotchets, or granules. Radial shields rather narrow, separated more or less, mostly concealed by cuticle. Arm-spines usually long and slender, unequal, more or less rough, often glassy or translucent, often hollow. Dorsal arm-plates usually all separated by the side arm-plates; sometimes, on a few basal joints, they are slightly in contact.

To this section a large majority of all the described species belong.

Group B.—*Ophientodia* Ver., 1899*a*, p. 41.

Two, three or four tooth-papillæ clustered at the tip of the jaws. Otherwise nearly as in section A. Distal oral papillæ not clustered.

The published figures of several species shows two paired papillæ, directed centrally, at the tip of the jaws. They may not always stand on the dental plate and in such cases should be counted as oral papillæ, but in some cases they have been determined as true tooth-papillæ. Probably in this section there may be a central tooth-papilla that has been overlooked in some species, by reason of its position, high up on the jaw, or its smaller size. In some cases it may have been accidentally lost. But in some specimens either two or three papillæ occur on different jaws. Therefore, I consider the presence of *three* tooth-papillæ as the usual character of this division. The species need revision as to the tooth-papillæ. (See also group VII, page 338.)

a.—Radial shields rather small, narrow, mostly concealed.

O. scutata Lym. Three tooth-papillæ; eight to ten thorny arm-spines. Radial shields long and narrow, sometimes naked.

O. cuspidata Lym. Three tooth-papillæ.

O. pectinula Ver. Three or four tooth-papillæ. Dorsal arm-plates pectinate on the outer edge.

aa.—*Ophioscalus* Ver., 1899*a*, p. 42. Radial shields large, wide, closely joined, naked. Disk-scales covered with rough spinules. Arm-spines approximate dorsally.

O. echinulatus Lym. Arm-spines ten, very thorny and glassy. Tentacle-scales spiniform, two on the first joint. Two or three tooth-papillæ.

Group C.—*Ophiectodia* Ver., 1899*a*, p. 42.

Outer oral papillæ (oral tentacle-scales) several, forming a cluster or a double row, some often standing on the lower face of the jaw or adoral shield. Tooth-papillæ one to three, or more. The oral papillæ are clustered nearly as in typical *Ophiomitra*.

O. enopla Ver. Tooth-papillæ, one or two.

O. rosea Lym. Tooth-papillæ clustered, three or more.

O. spectabilis Sars. Tooth-papillæ three or four, in a cluster.

Series II.

Group D.—*Ophialcæa* Ver., 1899*a*, pp. 38, 42. Types, *O. Nuttingii* (Ver.) and *O. tuberculosa* (Lym.). (See p. 326.)

The dorsal arm-plates are broadly in contact, at least on many of the proximal joints. Disk-scales bear spinules or granules. Radial shields separate, sometimes more or less exposed distally, sometimes covered. Arm-spines rather short, few, nearly smooth, the rows not approximate dorsally. Oral papillæ nearly as in typical *Ophiacantha* (group A).

O. Nuttingii Ver., 1899*a*, p. 46. Arm-spines four, short. Oral-shield very large, ovate. Disk-scales more or less exposed, bearing conical spinules.

O. rufescens Kœhl. Off the Azores, 845 meters. Ventral plates contiguous. Arm-spines six, finely serrulate. Two large elongated tentacle-scales. Oral papillæ six or seven, outer one largest. Disk-scales covered with fine roundish granules. Distal end of radial shields naked.

O. tuberculosa Lym., '98. E. Indies. Disk and radial shields covered with cuticle and granules. Arm-spines four. One tooth-papilla. Three oral papillæ, the distal one broad and notched. Oral shield not large, transverse. Tentacle-scale single, small.

Group E.— *Ophientrema*, sub-gen. nov. Type, *O. scolopendrica* (Lym.).

Tentacle-pores and scales on one, or a few, basal joints and larger than usual,* farther out decreasing rapidly to a small or rudimentary size. Disk-scales concealed by granules. Radial shields sometimes partly exposed. Spines numerous, nearly smooth. Mouth-parts as in typical *Ophiacantha.*

O. granulosa (Lym.). Radial shields largely exposed, broad, in contact distally. Arm-spines ten, slender, the rows nearly approximate dorsally. Tentacle-pores of the first joint large, with one flat scale; of others small, with a narrow scale. Dorsal arm-plates all separate. Pacific.

O. scolopendrica (Lym. '83). Radial shields nearly concealed, close together. Arm-spines seven, unequal, the rows not approximate dorsally. Tentacle-pores large on four joints, with a small scale, rudimentary or lacking distally. Dorsal arm-plates joined on a few basal joints. European.

Group F.— *Ophiomitrella* Ver., 1899*a*, p. 39. Type, *O. lævipellis* (Lym.).

Disk-scales visible, bearing granules or spinules. Radial shields partly naked, not large, wide apart. Arm-spines slender, thorny or serrulate; the rows approximate dorsally in the type. One tooth-papilla. In the type-species a pair of special, distal, oral tentacle-papillæ, on the first under arm-plate,† directed into the mouth-slit. Adoral shields wide. Otherwise the mouth parts are nearly as in typical *Ophiacantha.*

O. lævipellis (Lym., '83). Arm-spines eight, slender, thorny. Disk-scales naked or partly granulated. Upper arm-plates separated.

Group G.— *Ophiacanthella* Ver., 1899*a*, p. 39. Type, *O. Troscheli* (Lym.).

Radial shields naked, long, parallel, in contact by their edges. Dorsal arm-plates largely joined. Three tooth-papillæ. Arm-spines nearly smooth.

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* Several species that have been referred to *Ophiomitra* also have this character. (See *Ophiomitra*, section AA, p. 351.)

† The two papilliform appendages of the first under arm-plate are here supposed to be movable, but with the published figures and descriptions it is not always possible to distinguish them from the solid, immovable, crest-like lobes which are present on these plates in the same position in many species, including *O. bidentata.* Among extralimital species, these papillæ are found in some species, such as *O. serrata* Lym., that have the disk-scales and radial shields concealed.

Series III.

In the following groups the oral shield is separated from the side arm-plates by the adoral shields.

Group H.—*Ophiopora* Ver., 1899*a*. Type, *O. Bartletti* (Lym.).

Tentacle-pores all large and open. No tentacle-scales.

Group I.—*Ophiolimna* Ver., 1899*a*. Type, *O. Bairdii* (Lym.).

Spine-crest of the side arm-plates distally situated and oblique. Spines nearly smooth.

Disk granulose and spinulose. Jaws more or less granulose.

Group J.—*Ophiopristis* Ver., 1899*a*. Type, *O. hirsuta* (Lym.).

A row of distal oral papillæ alongside of the large outer ora tentacle-pore. Arm-spines partly flattened with serrulate edges. (See p. 347.)

Group K.—*Ophiotreta* Ver., 1899*a*, p. 40. Type, *O. lineolata* (Lym.).

One or two flat, distal oral papillæ by the side of the large oral tentacle-pore. Two or three tooth-papilla. Spines mostly terete, but sometimes flattened and with serrulate edges. (See p. 328.)

Group L.—*Amphipsila* Ver., 1899*a*, p. 55. Type, *A. maculata* Ver.

Oral papillæ form a simple row. Two or three tooth-papillæ in the marginal series. Disk-scales and radial shields naked, small. Tentacle-scale slender, spiniform or palmate. Arm-spines serrulate, flattened, hollow. (See p. 348.)

Ophiocopa Lym. also belongs in this series.

Ophiacantha, sens. ext.

Artificial groups of species from the West Indian region and from the East Coast of North America, arranged according to various special characters.

All the species appear in groups I and II. In these two groups all the northern species are indicated by an asterisk prefixed. These groups are not intended as natural sections of the genus, though they

may be so in some cases, but merely as aides for the comparison of the species. They may be considered as morphological tables. The genus in these XIII groups is taken as in Mr. Lyman's works.

For the natural subdivisions, see pages 329–333.

I.

Arm-spines long, thorny or prickly, more or less glassy.

a.—Rows of spines approximate dorsally on first or second joint beyond disk.

b.—Radial shields covered; disk spinulose.

O. aspera Lym., '78. Arm-spines ten, slender, very thorny.

O. pentacrinus Lütk. Spines nine or ten, long, very slender, slightly thorny.

O. pectinula Ver., sp. nov. Spines ten or eleven, very slender and glassy. Tooth-papillæ two to four. A cluster of oral tentacle-papillæ.

**O. millespina* Ver., '79. Spines ten. Disk spinules slender, with three or four long sharp branches.

**O. gracilis* Ver.,† '85. Spines four to six, short, except the upper basals; lower ones thorny. Disk-scales naked, with hour-glass shaped, thorny stumps.

**O. varispina* Ver., '85. Spines eight, little rough, glassy.

bb.—Radial shields largely exposed.

O. lævipellis Lym., '83. Spines seven or eight, little flat; naked disk-scales.

O. echinulata Lym., '78. Spines nine or ten, long; disk spinose. See under *Ophiomitra.*

aa.—Basal rows of spines not closely approximated dorsally.

O. stellata Lym., '75. Arm-spines seven, very thorny.

O. scutata Lym., '78. Spines nine or ten, slightly thorny.

**O. granulifera* Ver., '85. Spines eight or nine, part of them slightly thorny.

II.

Arm-spines, in the adult, not distinctly thorny, but often finely serrulate on the edges, especially the lower ones; mostly rather opaque, but often translucent in alcohol; usually hollow.

†This singular species, on reexamination, proves to belong to *Ophiothamnus.* Its long, wedge-shaped oral shields are widely separated from the arm-plates by the broad adoral shields.

a.—Spines slender, tapered, terete, or but little flattened; often nearly smooth, or only microscopically serrulate; rougher when young.

b.—Basal rows of spines approximate dorsally on the first or second joint.

c.—One odd tooth-papilla.

O. vepratica Lym. Arm-spines eight, long and tapered.

O. segesta Lym., '78. Disk-spines slender, mixed with thorny stumps.

**O. Bairdii* Lym., '83. Disk with granules and some tapered spines. Jaws granulated more or less.

**O. bidentata* (Retz.). Spines somewhat rough or serrulate, especially when young. Disk-spinules are small, thick, rough, obtuse stumps.

**O. abyssicola* Sars. Disk-spinules minute.

**O. aculeata* Ver., '85. Spines eight or nine, tapered, upper ones nearly smooth. Disk-spinules with three to five sharp points.

**O. anomala* Sars.† Spines eight or nine, all terete, tapered, finely serrulate; six arms.

**O. enopla* Ver., '85. Spines four or five, serrulate; outer oral papillæ clustered.

cc.—Two or three tooth-papillæ. Distal oral papillæ or oral tentacle-scales clustered.

**O. spectabilis* Sars. Disk-spinules large, tapered, acute.

bb.—Basal rows of spines not very closely approximate dorsally.

d.—Dorsal arm-plates, at base of arms, separated by side plates, or only slightly in contact.

**O. fraterna* Ver., '85. Disk covered with minute spinules having three to five sharp points.

**O. crassidens* Ver., '85. Disk with small tapered spines. Oral papillæ very stout.

O. Bartletti Lym., '83. (*Ophiopora* Ver., p. 345.) No tentacle-scales.

dd.—Dorsal arm-plates, at base of arms, distinctly joined.

e.—Disk and radial shields covered with spinules, or mixed spines and granules.

† This species is viviparous. One specimen from off Nova Scotia has several six-armed young clinging about the mouth and genital slits.

O. cosmica Lym., '78. Arm-plates only a little joined.

O. lineolata Lym., '83. Arm-plates broadly joined. Disk with grains and some spines.

ee.—Jaws also more or less granulated.

O. mixta (Lym., '78). Disk with grains and spines. (*Ophiolimna* V., p. 345.)

eee.—Disk granulated; radial shields partly naked.

f.—Radial shields joined. (*Ophiacanthella* V., p. 344.)

O. Troscheli Lym., '78.

ff.—Radial shields separated. (*Ophialcœa* V., p. 331.)

O. Nuttingii Ver., 1899*a*, p. 46.

aa.—Spines partly distinctly flattened and serrulate on the edges; the rows not approximate dorsally on the basal joints. Two or three tooth-papillæ. (*Ophiopristis* V., p. 347.)

O. hirsuta Lym., '75. Spines four or five, slender, part flat. Disk with long, very slender spines.

O. ensifera Ver., 1899*a*, p. 47. Spines four, stout, mostly flat. Disk with small, conical spinules.

O. cervicornis Lym., '83. Spines five, mostly slender, acute.

O. sertata Lym. Spines seven, translucent. Tentacle-scales two.

III.

Radial shields more or less exposed.

A.—Radial shields partly or wholly in contact.

a.—Radial shields rather wide, angular.

O. echinulata. Inner edges of radial shields wholly in contact. (See *Ophioscalus*, p. 331, also p. 342.)

aa.—Radial shields narrow and long.

O. Troscheli. Shields naked and largely in contact. (See *Ophiacanthella*, pp. 332, 344.)

AA.—Radial shields separated, not large.

b.—Never entirely concealed.

O. lœvipellis. Small, wide apart. (See *Ophiomitrella*, pp. 343, 352.)

bb.—Sometimes nearly or quite concealed.

O. sertata. Small, pear-seed-shaped.

O. scutata. Long and narrow.

O. ensifera. Small, narrow, usually largely covered. (See *Ophiopristis*, p. 347.)

O. Nuttingii. Crescent-shaped, narrow. (See *Ophialcæa*, p. 331.)

Several other species are apt to have the distal end of the radial shields more or less exposed. In many cases the covering is probably accidentally rubbed off.

IV.

Dorsal arm-plates, on basal part of arms, in contact, not separated by the side-plates.

a.—Dorsal arm-plates rather narrow.

O. lineolata. Ventral plates slightly separated. (See *Ophiotreta*, pp. 333, 347.)

aa.—Dorsal arm-plates broad.

b.—Dorsal plates extensively joined. (See *Ophiacanthella*, p. 344.)

O. Nuttingii. Ventral plates in contact.

O. Troscheli. Ventral plates separated.

bb.—Dorsal plates little joined.

O. cosmica. Ventral plates separated.

O. mixta. (See p. 346.)

V.

Tentacle-pores all unusually large.

O. Bartletti. No tentacle-scales. (See *Ophiopora*, p. 345.)

O. cervicornis. Two spiniform tentacle-scales. (See *Ophiopristis*, pp. 333, 347.)

VI.

A cluster of three or more tooth-papillæ at the tip of the jaw.*

O. lineolata (three or four tooth-papillæ).

O. scutata (three or four, often only two visible below).

* Several extralimital species belong to this group, such as *O. Valenciennesi* Lym., with three tooth-papillæ and one oral tentacle-scale; *O. cuspidata* Lym.; *O. marsupialis* Lym.; *O. rosea* Lym.; the last has a cluster of tooth-papillæ and also several oral scales. (See p. 338, note, and p. 348.)

O. sertata (three, only two visible below).

O. Troscheli (three tooth-papillæ).

O. spectabilis (three to five tooth-papillæ; a cluster of distal oral papillæ.

O. pectinula Ver. (two or three tooth papillæ; three or more distal oral tentacle-papillæ).

VII.

A pair of tooth-papillæ (or apparent tooth-papillæ) close together, at the tip of the jaw; no odd median one visible from below. (In some species the odd papilla may be concealed by the pair below it, when it is actually present, but published figures and descriptions are not definite enough to determine this in many cases; in some cases it may have been accidentally broken from the type-specimen. It certainly seems to be the normal condition, in group *a*, to have only two.)

a.—A distal cluster or row of special oral tentacle-scales. See *Ophiopristis*, p. 347.

O. cervicornis.

O. ensifera.

O. hirsuta.

aa.—Only one or two distal oral tentacle-scales.

O. Bartletti. No tentacle-scale on arms.

O. echinulata. Two spiniform tentacle-scales on arms.

VIII.

A cluster of oral papillæ or oral scales near the outer corner of the mouth-slits, at the outer oral tentacle-pore, or else one or two special oral scales by the side of the tentacle-pore, which is on, or nearly outside of, the margin of the mouth-slit. (Published figures are often inaccurate as to this character.)†

a.—Several distal oral tentacle-scales or papillæ to each pore.

O. cervicornis. About four spiniform distal papillæ in a row.

O. pectinula Ver. Three to four distal papillæ.

**O. enopla.* Four to six distal papillæ in a cluster.

† Several extralimital species belong to this group; among them are: *O. rosea* Lym. (in subsection *a*); *O. marsupialis* Lym.; and *O. Valenciennesi* Lym. (in *aa*.)

O. hirsuta. Two to four papillæ in a row.
O. ensifera. Four to five papillæ in a curved irregular row.
* *O. spectabilis.* Three or four in an irregular group.

aa.—One or two special distal oral scales or papillæ, usually attached to the adoral plate ; oral tentacle-pore large.

O. Bartletti. One, spiniform, distal oral papilla.
O. lineolata. Two flat papillæ.
O. sertata. Two flat papillæ.
O. lævipellis. One flat papilla, attached to first arm-plate.

IX.

A pair of small, apparently movable, oral papillæ attached to the proximal end of the first under arm-plate, which is emarginate.† In most species of the genus there are, in this place, two flat, usually fixed, processes or crests. It is generally impossible to tell, from published figures, the character of these parts. They are generally badly represented.

* *O. anomala.*
O. lævipellis. (See group VIII, *aa.*)

X.

Oral papillæ unusually large and stout.

* *O. crassidens.* Three or four thick and rough papillæ, the distal ones smaller.
* *O. varispina.* Three or four broad, flat, obtuse papillæ.

XI.

Tentacle-scales of peculiar or unusual forms, or spiniform.

a.—Tentacle-scales elongated ; flat, spatulate, or lobate distally.

O. aspera. End of tentacle-scale branched or thorny.
* *O. varispina.* End spatulate.

aa.—Tentacle-scales elongated, slender or spiniform.

O. echinulata. Scales dagger-shaped ; two pairs on first joint.
O. cervicornis. Two, spiniform, slender.
O. Troscheli. One, long, acute.

† Of extralimital species, *O. serrata* Lym., *O. cornuta* Lym., and *O. Valenciennesi* Lym. belong to this group.

O. vepratica. One, large, conical.
O. segesta. One, small, acute.
* *O. gracilis.* One, slender, palmate, distal ones acute.
O. pectinula V. Spiniform, two or three on first joint.

XII.

Tentacle-scales wanting. Adoral shield as in XIII. (*Ophiopora* V.)
O. Bartletti (see p. 345). Outer oral tentacle-pore large, with a conical papilla.

XIII.

Adoral shields long, usually trilobed; the distal lobe separates the oral shield from the side arm-plate. In all typical species of the genus the oral shield and adoral shield both join the side arm-plate.

A.—One or two tentacle-scales.
B.—Disk-scales mostly concealed.

a.—Jaws not granulated, or only slightly so. (*Ophiopristis* V.)
b.—A row or series of special distal oral papillæ.

O. hirsuta. (See p. 336.)
O. ensifera. (See p. 336.)
O. cervicornis. (See p. 347.)

bb.—One or two distal oral papillæ or scales. (*Ophiotreta* V.)†
O. sertata. (See p. 348.)
O. lineolata. (See p. 348.)

AA.—Jaws granulated. (*Ophiolimna* V.)

* *O. Bairdii.* (See p. 346.)
O. mixta (Lym., as *Ophiochæta*). See p. 346.

BB.—Disk-scales entirely exposed. Radial shields more or less naked. Adoral shields broad distally. (*Ophiothamnus.*)

* *O. gracilis* Ver. Disk-scales bear hour-glass-shaped spinules with a terminal group of points.

AA.—No tentacle-scales. Tentacle-pores all very large and open. (*Ophiopora* V.)

O. Bartletti. (See p. 345.)

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† Among extralimital species that belong to this group, are *O. placentigera* (Lym.) and *O. Valenciennesi* (Lym.).

Ophiacantha scutata Lyman.

Ophiacantha scutata Lym., Bull. Mus. Comp. Zool., vol. v, p. 229, pl. i, figs. 1–3, 1878; op. cit., vol. x, p. 261, 1883 (variations).

Specimens sent to me by Mr. Lyman differ somewhat from his figures and descriptions.

The oral papillæ may be either three or four on different jaws of the same specimen; they are rather stout, spiniform, the inner largest, and all appear to be on the buccal plate, but the jaw-plates and adoral shields are so closely united together that the sutures are mostly invisible. There is often an extra outer papilla of small size, which is situated at the union of the buccal and adoral plates, outside the oral tentacle-pore, which is large, but situated inside the mouth-slit. Tooth-papillæ may be from two to four on different jaws of a large specimen. Usually there is a stout median one with a pair of smaller ones just above it, invisible from below, and another small median one outside. The last is often lacking, and the upper pair may be replaced by a single one, which is, perhaps, absent in small specimens. The oral shield is more nearly transverse-elliptical than figured, with a more obtuse inner angle. The madreporic shield is longer than the others and more rhombic, thickened, with a median concavity. The adoral shields of a large specimen are smaller than figured, narrow and tapered proximally, and the ends do not meet medially, but in small specimens they are nearly as figured and meet medially. The first under arm-plate is small, rounded, emarginate on the inside, with a small vertical crest at each side, directed inward.

The under arm-plates of the larger specimen are unlike the figure; they are narrower and longer, with the distal end projecting and strongly convex; the proximal end is very obtusely angulated or subtruncate; a little farther out on the arm they become more oblong, with the outer end more projecting and the inner end truncate and scarcely narrowed. They are slightly separated.

Tentacle-scales, on two or three of the basal joints, are flat, erect, lanceolate, and cuspidate; occasionally, in the larger examples, there are two on the first joint. Beyond the fifth or sixth joint they become slender, acute, spiniform. The first two or three pairs of tentacles are decidedly larger than those beyond.

Arm-spines, in the largest rows, are ten, shaped about as figured, with numerous small, sharp prickles on all sides. The basal rows

approximate dorsally, but not so closely as in some other species. Upper arm-plates nearly as figured, transverse lozenge-shape, with the distal edge convexly curved at first, but becoming prominent and angulated farther out.

The whole upper surface of the disk, including the radial shields, is thickly covered with small, short, thorny spinules or stumps, terminated by three to five or more short, sharp points. Diameter of disk of largest specimen, 14^{mm}; of smallest, 7^{mm}.

Off Barbadoes, 200 fathoms, Blake Exped.

Ophiacantha (Ophiectodia) pectinula, sp. nov.

Disk-scales small, entirely hidden by cuticle and bearing crowded, very slender, elongated spinules, thorny on the sides and at the tip. Radial shields small, near together, entirely hidden by cuticle and spinules.

Two to four clustered tooth-papillæ. Oral papillæ numerous, nearly equal, compressed, spiniform, smaller than the tooth-papillæ; four or five form a regular lateral row; five or six more distal ones form a cluster or two rows, and serve as oral tentacle-scales. Oral shield broadly pelecoidal, wider than long, with a slightly convex distal lobe. Adoral shields about as large as the oral, oblong-lunate, meeting within.

Tentacle-scales long, acute, spiniform, thorny, two at the basal pores. Arm-spines long, very slender, thorny, very acute; some of the rows nearly approximate dorsally at base of arms, where there are nine or ten in a row. Dorsal arm-plates small, quadrant-shape, the sides nearly straight, the outer end convex with a marginal row of minute, sharp denticles. Under arm-plates small, widely separated; the inner end forms an obtuse angle; the outer end is convex, prominent, side arm-plates prominent, meeting above and below.

Diameter of disk, 8^{mm}; length of arms, broken at tips, about 40^{mm}.

West Indies, Blake Exped., 1883.

This was sent to me by Mr. Lyman as *O. echinulata*, with which it does not agree. The type of the latter has broad naked radial shields, in close contact, and the oral papillæ are much fewer and are figured as forming a simple row. The spines and tentacle-scales are similar, though the basal rows of spines approximate more closely dorsally.

Ophiomitrella Ver., 1899*a*, p. 39. (See p. 336, and p. 352.)

Ophiomitrella lævipellis (Lym.) Ver.

Ophiacantha lævipellis Lym., Bull. Mus. Comp. Zool., vol. x, p. 259, pl. vi, figs. 82–84, 1883.

Ophiomitrella lævipellis Verrill, Ophiur. Bahama Exped., v, p. 39, 1899.

About twenty specimens of this species were sent to me by Mr. Lyman. They show considerable variation among themselves, and all differ more or less from his figures and description.

The disk is strongly five-lobed, owing to a deep incurvature of the interradial areas. The upper side is closely covered with small thin scales, which are usually smooth and nearly destitute of granules, but in some examples there are a few scattered, low, verruciform grains, especially near the margins; in others the grains are thinly scattered over nearly all the surface; in some cases part of the grains are conical. The scales themselves vary somewhat in size and distinctness.

The radial shields appear to be long and narrow and nearly parallel; a narrow ridge, in dry specimens, often runs inward nearly to the center from each shield; only the ends of the shields are commonly exposed; this naked part varies in form and extent, but is usually long, narrow, wedge-shaped, widest distally, and the ends often project somewhat beyond the edge of the disk over the base of the arm and may bear a few marginal granules. The ends of the shields are sometimes near together, being separated by a space less than half their breadth; in other specimens they are separated more than their breadth.

Oral papillæ vary in number, even on the different jaws of the same specimen, from three to five; most frequently there are three in the regular series, with a smaller and much shorter distal one, just at the distal end of the adoral shield and above the large pore of the outer oral tentacle. In many cases this outer papilla develops to full size, like the next one, which is stout, erect, obtuse, larger than those that follow it; the latter are usually compressed vertically, subacute; the inner one is a little longer and more conical. Attached to each inner corner of the first arm-plate there is a small vertically flattened scale or papilla that appears to be movable; it guards the oral tentacle on the inside and is sometimes wanting. It corresponds to a similar process which in several other species seems immovable.

Tooth-papilla one, or perhaps none, for the odd papilla at the tip of the jaw agrees nearly in size and form with the true teeth. It

varies in form, however, even on the different jaws of the same specimen. It is usually ovoid, or obtusely lanceolate, or even obovate; sometimes it is acute or mucronate at tip, and then it differs a little more decidedly from the teeth. It stands on the tip of the dental plate.

The oral and adoral shields are thickened and prominent, shaped nearly as in the figure by Mr. Lyman. The oral shield is small and somewhat fan-shaped, or rather pelecoidal, for the inner lateral edges are strongly incurved. In one specimen the oral shields were unusually narrow and acutely angled proximally. The adoral shields are relatively large, lunate, confined to the proximal side of the oral shield.

First under arm-plate is small, irregularly six-sided, strongly emarginate within. The second is much broader than long, curved distally, and obtusely angled proximally. Those following are still shorter, transversely narrow-elliptical, with a very obtuse proximal angle, or nearly truncate and broadly curved distally, often showing a slight median incurvature of the edge, which becomes more distinct on those farther out. They are thick and widely separated by the side arm-plates, which lie in grooves. More distally they become more nearly square, with the inner end more angulated.

Tentacle-scale small, spiniform, subacute, rather rough, becoming more slender farther out. All the tentacle-pores are small.

Arm-spines about as figured, except that many of them are more thorny, especially those near the base of the arms and in the upper series, most of which have irregular sharp divergent thorns; farther out they are mostly minutely serrulate. They are not usually distinctly flattened, as stated, but slender, terete, tapered, acute. The rows are closely approximate dorsally on the second and third joints, becoming separated farther out.

Upper arm-plates thick, swollen, widely separated, rather triangular or quadrant-shaped, with an obtuse proximal angle and a broadly convex distal edge. On the middle of the proximal part there is a small, wart-like elevation.

Diameter of disk of those described above, 3 to 6^{mm}.

Off St. Vincent, 88 and 124 fathoms. Blake Exped.

Ophiacanthella Verrill, 1899*a*, p. 39. Type, *O. Troscheli* (Lym.) Ver.

Three terminal tooth-papillæ in a group. Radial shields long, narrow, largely in contact, more or less naked. Disk-scales obscured by cuticle, granulose or spinulose. No special oral tentacle-scales.

Oral papillæ all similar. Dorsal arm-plates largely in contact. Tentacle-scales one or two, all similar. Spines slender, finely serrulate or nearly smooth.

This genus is, in most respects, closely related to *Ophiomitra*. It differs in having the disk-scales mostly concealed by cuticle; in having three apical tooth-papillæ, instead of one; in having the dorsal arm-plates joined; and in the smoothness of the spines.

It is separated from *Ophiacantha* especially by the naked and contiguous radial shields, and from the typical section of that genus by having three tooth-papillæ and contiguous dorsal arm-plates.

Ophiopora Ver., 1899*a*, pp. 39, 43. Type, *O. Bartletti* (Lym.) Ver.

Adoral plates with two distal lobes, one of which embraces the lateral edge of the oral shield and separates it from the side arm-plates, as in *Ophiopristis*. No tentacle-scales; tentacle-pores all very large and widely open. Two or three tooth-papillæ. Outer oral tentacle-pore is submarginal and furnished with one special, acute, papilla or oral tentacle-scale on the adoral shield. Disk-scales, above, and the radial shields are concealed by cuticle and spinules; on the under side the scales are visible. Arm-spines few, nearly smooth. Dorsal arm-plates are separated by side plates.

This genus is closely allied to *Ophiolimna*, but differs in the large open tentacle-pores, without scales.

Ophiopora Bartletti (Lym.) Ver.

Ophiacantha Bartletti Lym., Bulletin Mus. Comp. Zoöl., vol. x, p. 256, pl. v, figs. 73–75, 1883.
Ophiopora Bartletti Ver., Ophiur. Bahama Exp., Bull., v, p. 39, 1899.

This is the only known species of this group. The disk is covered by slender acute spinules. The four arm-spines are small, tapered, rather short, nearly smooth. The side arm-plates are not prominent.

West Indies, 291 fathoms, Blake Exped.

Ophiolimna Ver., 1899*a*, pp. 40, 44. Type *O. Bairdii* (Lym.) Ver.

Adoral shields trilobed; one distal lobe extends back between the oral shield and first side arm-plate, so that the oral shield is detached from the arm. The jaws may bear more or less granules. Disk-scales and radial shields covered with granules, or spinules, or both.

Side arm-plates prominent, with the oblique, spine-bearing crest near the distal margin, so that the spines are directed more or less distally, especially on the distal half of the arm. One or two tooth-papillæ. Several simple oral papillæ in a regular row, the outer ones broader. One or two tentacle-scales. Arm-spines tapered, nearly smooth, rather short.

This genus agrees with *Ophiacantha* and *Ophiomitra* in its mouth-parts, but differs from both in the more oblique position of the rows of arm-spines and in the separation of the oral shields from the side arm-plates. In the last character it agrees with *Ophiopristis*, *Ophiopora*, etc.

The type, *O. Bairdii* (Lym., 1883,)* was taken by the Blake, off the east coast of the United States, in 1242 and 1394 fathoms, and by the United States Fish Commission Steamer Albatross in 1390 fathoms, in the same region.

This species has seven or eight smooth, acute spines, of moderate length ; the rows closely approximate dorsally ; the disk bears small acute granules and a few short spines ; jaws partly naked, but with some granules; outer oral papilla (oral tentacle-scale) broad and flat; one tooth-papilla ; one small tentacle-scale ; oral shield broadly obovate; dorsal arm-plates scarcely joined on basal joints. The spine-crests are distally placed on the side arm-plates, and the spines are mostly directed distally, or often lie nearly parallel to the arms.

Ophiolimna mixta (Lym.) Verrill.

Ophiochæta ? mixta Lyman, Bulletin Mus. Comp. Zool., vol. v, p. 222, pl. ii, figs. 40–42, 1878; Voyage Challenger, Oph., vol. v, p. 110, pl. xxxix, figs. 15–17, anatomy, 1882.

Ophiolimna mixta Ver., Ophiur. Bahama Exped., Bull., v, p. 40, 1899.

This species has two large flat tentacle-scales; seven smooth arm-spines ; two tooth-papillæ; six oral papillæ; jaws granulated ; dorsal and ventral arm-plates not separated by the side arm-plates on the basal joints ; disk crowdedly covered with granules mixed with some slender spines.

The internal structure, as figured by Lyman, is much like that of *Ophiacantha*. The radial shields, seen from within, are broad, three-cornered, separated. It does not appear to be closely allied to *Ophiochæta*.

West Indies, in 160 to 576 fathoms, Blake Exped.

*Bulletin Mus. Comp. Zoöl., vol. x, p. 256, pl. v, figs. 70–72 (as *Ophiacantha*).

Ophiopristis Ver., 1899*a*, pp. 39, 44, 47. Type, *O. hirsuta* (Lym.) Ver.

Adoral plates elongated, three-lobed; the distal end is two-lobed; one distal lobe joins the first under arm-plate; the other joins the first side arm-plate and separates it from the oral shields, so that the oral shield is quite detached from the side arm-plates, as in *Ophiocopa*. Disk-scales bear spinules or granules. Radial shields are separated, mostly concealed by cuticle. Arm-spines rather long; in the typical group, mostly flattened and with regularly serrulate edges. The rows are not approximate dorsally. Tentacle-scales one or two.

Tooth-papillæ two to four. Oral papillæ numerous; two or more of these are special oral tentacle-papillæ or scales, guarding the large outer oral tentacle-pore, which is on or near the margin of the jaw and is conspicuous. First under arm-plate is concave and has a flat process on each inner corner.

Synoptical table of Ophiopristis and Ophiotreta.

A.—Typical *Ophiopristis*. A row of several small conical or slender, distal, oral tentacle-papillæ outside the large pore. Arm-spines partly flat with serrulate edges. Two or three tooth-papillæ. Dorsal arm-plates separated, but rows of spines not approximate.

O. hirsuta Lym. (See p. 336.)

O. ensifera Ver. (See p. 336, Pl. XLIII, fig. 4.)

O. cervicornis Lym. A regular row of four or five slender oral tentacle-papillæ. Two tooth-papillæ. Two spiniform tentacle-scales; the pores very large and open. Disk and radial shields covered with fine granules and small acute spinules; some spinules on upper arm-plates. Six short flat spines serrate on the edges.

AA.—*Ophiotreta* Verrill, 1899*a*, p. 40. (See p. 333.) Spines terete or only little flattened. One or two, rarely three, distal oral papillæ or scales at the large oral tentacle-pore. Two to five or more tooth-papillæ.

a.—Dorsal arm-plates joined. Rows of spines not approximate dorsally. Spines nearly smooth. Tooth-papillæ three to five. Distal oral tentacle-scales flat, blunt, two or three. Two tentacle scales on several basal joints; one is flat, the other spiniform.

O. lineolata (Lym.). Disk and radial shields closely covered with granules and spines. Jaws bear granules. Arm-spines seven.

aa.—Dorsal arm-plates separate. Rows of spines not closely approximate. Two or three tooth-papillæ. Spines nearly smooth or finely serrulate or thorny; some a little flattened.

O. sertata (Lym.). Arm-spines seven. Tentacle-scale large, flat. Two flat, distal, oral scales. Disk covered with granules and tapered spines. Radial shields sometimes naked, ovate, separate, but usually concealed.

O. Valenciennesi (Lym.). Tooth-papillæ three; oral tentacle-pore large, marginal, with a large round distal scale ; a pair of small papillæ on first under arm-plate ; two large tentacle-scales. Spines four, with blunt thorny tips. Disk granulated.

To this group may also be referred *O. placentigera* (Lym.), off Fiji Is., 1350 fath. It has three tooth-papillæ ; a large, broad, oral tentacle-scale; granulated disk ; six smooth spines ; one tentacle-scale.

Amphipsila Verrill, 1899*a*, p. 55. Type, *A. maculata* Ver.

PLATE XLIII. FIGURES 5, 5*a*.

Disk rounded, covered with thin, naked scales, above and below. Radial shields narrow, separated, naked. Arm-plates distinct, above and below. Arm-spines of moderate length, numerous (five to twelve), serrulate. Oral shields clearly visible, at least when dry. A simple row of oral papillæ. Only two or three conical apical papillæ, in a row; these may be considered as tooth-papillæ, but there is no distinct cluster of inner tooth-papillæ, below the teeth, as in *Ophiopsila*. Tentacle-scale spiniform.

I have separated this genus from *Ophiopsila*, as understood by Lyman, for he included in the latter *A. fulva* (Lym.), which is closely allied to our type-species.

In true *Ophiopsila* (type, *O. aranea*), to which *O. Riisei* of the West Indies also belongs, there is a cluster of many special tooth-papillæ, within the mouth, below the teeth, as in *Ophiocoma*, and the disk is covered with thick cuticle, nearly or quite concealing the scales. It appears to belong to the family *Ophiocomidæ*, while our genus seems to be closely related to *Ophiacantha*, with which it agrees in its mouth-parts and spines. It differs from typical *Ophiacantha* it its naked disk-scales and radial shields, in having the upper arm-plates joined, and in the distal prolongation of the adoral plates, much as in *Ophiopristis* and *Ophiolimna*, though less distinct, owing to its narrowness.

Ophiomitra Lyman.

Bulletin Mus. Comp. Zoöl., vol. i, p. 325, 1869; Voyage Challenger, v, pp. 202–209, 1882, pl. xlv, figs. 4–6, (anatomy).
Verrill (restricted), Oph. Bahama Exped., Bull., v, p. 57, 1899.

This genus is very closely allied to *Ophiacantha*. The only special distinctions given by Lyman are the larger size and nakedness of the radial shields and the naked or nearly naked scales of the disk.

Mr. Lyman also described the disk of the type-species as rounded and cap-like,—a character due, perhaps, to immaturity, for in large specimens of that species the interradial margins are incurved or emarginate.

When adult the type-species (*O. valida* Lym.)* has numerous spiniform, clustered oral papillæ and tooth-papillæ. The distal oral tentacle-pore is large and sub-marginal, partly sheathed by proximal processes from the concave first under arm-plate and inner side of the jaw. The adoral shields are very broad, but wholly proximal to the small oral shields. The basal tentacle-pores are larger and furnished with two prominent tentacle-scales. The large, broad radial shields are largely in contact. The disk-scales are not large, of nearly uniform size, without specialized marginal ones, and bear coarse, short, clavate, thorny stumps. The arm-spines are numerous, somewhat thorny and glassy. The dorsal arm-plates are slightly separated by the side-plates.

Most of the species subsequently described by Mr. Lyman and others differ much from the type, in several characters.

They nearly all have a single odd tooth-papilla and a simple row of oral papillæ, as in typical *Ophiacantha*. The interradial marginal scales are usually large and specialized. The radial shields are often entirely separate and in some cases not particularly large.

In fact, they have little in common with the type, except the partial nakedness of the radial shields and disk-scales,—characters also found in species of *Ophiacantha*.† Therefore it seems necessary to subdivide the genus.

* The specimens originally described and figured by Lyman were all immature, and had not developed the true character of the mouth-parts.

† One species (*O. Normani*) referred to this genus by Mr. Lyman does not agree with it even in these characters, for the separated radial shields are no larger and no more exposed than in several species of *Ophiacantha*, and its disk-scales are granulated. In its arm-spines, which are smooth and only four in

Ophiotrema of Kœhler seems to be very closely related to typical *Ophiomitra.*

Like the latter, it has clustered tooth-papillæ and oral papillæ, with a large, conspicuous distal oral tentacle-pore and special papillæ around it. The tentacle-pores are large and surrounded by several small acute spinules. Disk-scales are small, visible, bearing acute rough spinules. Radial shields are small, naked, separate, divergent. Arm-spines five, serrulate.

O. Alberti Kœhl., '96, the type, is from off the Azores.

Certain species referred to *Ophiomitra* by Kœhler appear to belong to *Ophiomitrella.* (See p. 352.)

Synoptical table of the species that have been referred to Ophiomitra (sens. ext.) *and Ophiomitrella.*

Group A.—Typical *Ophiomitra.*

Tooth-papillæ several, clustered. Oral papillæ numerous, clustered distally. Distal oral tentacle-pore large. Radial shields large, naked, usually joined. Disk-scales visible, all of moderate size, bearing stumps or spinules. Arm-spines thorny and usually glassy. Two or three tentacle-scales on the basal joints, in the type. Adoral shields broad, proximal to the oral shields. Interradial margins of disk somewhat incurved, sometimes convex, not deeply notched.

a.—Radial shields largely in contact.

b.—Disk-scales bear short clavate or capitate stumps. Rows of arm-spines not approximate dorsally.

O. valida Lym., '69. Arm-spines nine or ten, solid, not very long, roughly serrulate or thorny.

bb.—Disk-scales bear longer and shorter, tapered, thorny spines. Rows of spines approximate dorsally.

O. ornata Ver., 1899*a*. This Vol., pl. XLIII, fig. 3. Arm-spines long, slender, thorny.

aa.—Radial shields divergent, in contact only distally. Arm-plates separate above and below.

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number, it differs from all the species of *Ophiomitra*. Therefore I have referred it to *Ophiacantha*, with which it agrees in its mouth parts. (See p. 329.)

Another species (*O. exigua* Lym.) I refer to *Ophiothamnus*. (See p. 328.) This, also, has smooth spines, and the small oral shield is separated from the side arm-plates by the large adorals.

**O. spinea* Ver. Oral papillæ not very numerous distally. Disk-scales small, with small conical spinules. Arm-spines eight or nine, rough, hollow, the rows not approximate dorsally. One or two tentacle-scales.

AA.—*Ophioplinthaca*, gen. nov. Type, *O. dipsacos* Lym. One odd tooth-papilla, oral papillæ in a nearly simple series, not clustered distally. Interradial margins of disk notched or deeply emarginate. Marginal and submarginal disk-scales large and specialized. Arm-spines thorny and glassy, usually hollow. Radial shields large and broad, naked or nearly so. First tentacle-pore decidedly larger, with two or more scales. Oral shield joins the first side arm-plates.

B.—Radial shields in contact along most of their length. Rows of spines not approximate dorsally.

c.—Upper arm-plates distinctly separated by the side plates.

O. dipsacos (Lym.). Arm-spines six, hollow, very thorny, the two upper ones very long. First tentacle-pore with two scales.

cc.—Upper arm-plates on basal joints slightly joined, or barely separate. Two or more distal oral tentacle-scales, similar to other oral papillæ.

O. incisa (Lym.). Arm-spines five or six, flattened, thorny on edges. Three to six tentacle-scales at first pore, one or two farther out. Disk-scales with few, nearly smooth, conical spinules.

BB.—Radial shields not in contact, or only slightly so distally. Spines glassy and thorny, the rows not approximate dorsally.

d.—Radial shields in contact at the distal ends, very large and wide.

e.—Upper arm-plates separated.

O. carduus (Lym.). Spines six, very thorny. Disk-scales with thorny stumps, marginal scales very large. Tentacle-scale one, lobate.

ee.—Upper arm-plates, on basal joints, not separated by side plates. First tentacle-pore larger, with two or three scales. A flat oral tentacle-scale.

O. plicata (Lym.). Radial shields joined distally in young; separate in adult. Disk-scales with small, conical spinules. Arm-spines

five or six, short, very thorny. Distal edge of under arm-plates bent downward.

dd.—Radial shields well apart, with intervening rows of scales.

f.—Upper arm-plates not separated by the side plates. Two tentacle-scales on first joint.

O. Sarsii (Lym.). Radial shields rather small, far apart. Disk-scales with small conical spinules. Arm-spines seven or eight, very thorny. Tentacle-scale lobate. A stout oral tentacle-scale.

ff.—Upper arm-plates separated by the side plates. Disk-scales coarse; marginal ones larger.

O. chelys (Lym.) Radial shields narrow, sunken. Disk with small conical spinules. Arm-spines six, hollow, very thorny. One tentacle-scale.

AAA.—*Ophiomitrella* Ver., 1899*a*, p. 39. (See p. 343.) Radial shields small, wide apart, naked. Disk-scales all nearly alike, not very large, outlines easily visible. One tooth-papilla. Oral shields join the side arm-plates. Interradial margins of the disk not deeply emarginate and without large scales. Disk bearing scattered granules or stumps.

g.—Arm-spines serrulate, the rows not approximate dorsally.

O. globulifera (Kœhler, '95). Arm-spines five. Disk-granules glassy, spherical. Europe, 1700 meters.

O. cordifera (Kœhler, '96). Arm-spines six or seven. Disk with small capitate granules. Azores, 1143 meters.

gg.—Arm-spines thorny and glassy, the rows approximate dorsally. A special outer oral tentacle-scale on the first under arm-plate.

O. lævipellis (Lym., as *Ophiacantha*). Seven or eight spines. Disk-scales naked or sparsely granulated ; all small. Disk pentagonal. (See also page 343.)

O. cornuta (Lym., as *Ophiacantha*). Spines eight. Disk rounded, bearing small thorny stumps; a larger scale between the radial shields. (See p. 339, note.)

AAAA.—Radial shields very large and in contact, covering most of the disk. Oral shields small, triquetral, not joining the side arm-plates; adorals large and broad. Arm-spines smooth or nearly so, the rows not approximate dorsally.

O. exigua (Lym.). Disk-scales few, coarse, with few thorny stumps. Arm-spines six, rather short, tapered; oral papillæ three, the outer one on the adoral shield. Tentacle-scale one.

The last named species should, I think, be referred to *Ophiothamnus*, with which it agrees well in all external characters. (See p. 350.)

O. Normani Lym., omitted from the table, is to be referred to *Ophiacantha* (typical group) as already stated (p. 349, note). It has small and rather widely separated radial shields and four smooth arm-spines.

Ophiomitra valida Lyman.

Ophiomitra valida Lyman, Bull. Mus. Comp. Zool., i, 10, p. 325, 1869; op. cit., x, p. 264, 1883; Lyman, Ill. Cat. Mus. Comp. Zool., vi, pl. ii, figs. 4–6; Lyman, Report Voy. Challenger, Zool. Ophiuroidea, v, p. 209, pl. xli, figs. 4–6, 1882.

Ophiomitra cervicornis (young) Lyman, Ill. Cat. Mus. Comp. Zool., viii, pt. ii, p. 14, pl. ii, figs. 19, 20, 1875; Bull. Mus. Comp. Zool., vol. v, part 9, p. 231.

Ophiomitra valida Verrill, Ophiur. Bahama Exped., Bull., v, p. 58, 1899.

Several large specimens of this species, sent by Mr. Lyman, differ considerably from his figures and description, which were made from immature specimens.

The most important differences are found in the mouth-parts. The largest of our specimens have very numerous oral papillæ and tooth-papillæ, crowded together in clusters, very much as in *Ophiocamax*. The tooth-papillæ often consist of a row of three, on or below the margin, and of two or three pairs above these, next the teeth, but frequently they are so crowded that no such regular arrangement can be made out. There may be as many as nine or ten on one jaw-apex. The distal oral papillæ form crowded groups of four to seven, or more, or they may stand in two rows, so as to cover or conceal most of the width of the jaw. They are all rather stout, spiniform, subacute. The distal oral tentacle-pore is large, marginal, exposed, nearly surrounded by sheath-like processes of the jaw and first under arm-plate, which is small and deeply concave. The oral tentacle is large, with a thickened basal part into which the distal part can be retracted.

Tentacle-scales two or three on the basal joints; farther out the pores and scales decrease in size rapidly. On the basal joints the inner scale is large, flat, lanceolate, erect, hollowed out on the side next the tentacle; the other is narrow, subacute. The under arm-

plates are smaller on the basal joints than farther out. They are broader than long, with a concave emargination on the distal edge.

The dorsal arm-plates are rather quadrant-shaped, with a broad lobe on the distal edge, and with prominent lateral angles. Some of the basal arm-plates are slightly in contact. Arm-spines ten, rather stout, roughly serrulate, blunt, the rows not approximate dorsally. The radial shields are larger, irregularly triangular, more or less encroached upon by the disk-scales and granules. The disk-scales are not large, all nearly equal, sparsely covered with short, coarse, rough, capitate stumps. The interradial margins have a small notch in dried specimens, but not larger scales.

Oral shields small, pelecoidal, with an acute inner angle, and a prominent convex outer end. Adorals about as large as the orals, wide, lunate, the surface finely granulous in appearance. In younger specimens the distal oral papillæ form one irregular row of about three or four around the pore.

Common throughout the West Indies in 10 to 1105 fathoms (Blake Expedition).

OPHIOCAMAX Lym. Type, *O. vitrea* Lym.

Ophiocamax Lym., Bull. Mus. Comp. Zool., vol. v, p. 156, 1878; Voy. Challenger, v, p. 209, 1882.

This genus is closely allied to typical *Ophiomitra*. Like the latter it has numerous tooth-papillæ in an apical cluster, and a cluster of distal oral papillæ, even more numerous than in *Ophiomitra*.

In the type-species there is also a special small distal plate (process of under arm-plate?) which bears two or three small papillæ directed proximally and serving as part of the papillæ for the large oral tentacle-pore.

The basal tentacle-pores have three or four elongated, erect tentacle-scales forming a sheath for the tentacles. Radial shields are wide and in contact. Disk-scales, which are usually visible, bear thorny spinules, but in the type species they are scarcely visible and closely spinulose in the adult.

The adoral shields are large and broad, situated in front of the oral shields.

Synoptical table of the species of Ophiocamax.

A.—Typical. Dorsal arm-plates, at base of arm, not separated by the side-plates. Rows of spines not approximate dorsally.

O. vitrea Lym. Disk closely covered with small, acute spinules, the scales nearly concealed. Tooth- and oral papillæ very numerous, slender, acute. Nine thorny arm-spines. Tentacle-scales large, obtuse.

O. hystrix Lym. Disk-scales visible, irregular, bearing few, short, conical, rough spinules. Radial shields in contact distally. Arm-spines eight, slender, the upper ones very long.

AA.—Dorsal arm-plates all separated. Rows of spines not approximate dorsally.

O. fasciculata Lym., '83. Arm-spines six, rather short, flattened, serrulate on the edges. Disk-scales plainly visible, bearing few small, tapered, acute spinules. Radial shields not very large, broad, wholly in contact. Dorsal arm-plates widely separated.

O. austera Ver., Ophiur. Bahama Exped., p. 60, pl. vi, figs. 1, 1*a*, pl. vii, fig. 2. Arm-spines seven, slender, the upper ones very long and very thorny, scarcely flattened. Disk-scales visible, bearing longer and shorter, rough, acute spinules. Radial shields large, triangular, extensively joined. Dorsal arm-plates nearly in contact on the basal joints. Four lanceolate tentacle-scales. A cluster of about six acute, distal, oral papillæ, pointing inward on each side, part of them arising from the lateral lobes of the deeply bilobed first under arm-plate. (See this vol., Plate XLIII, figure 2.)

OPHIOCHONDRINÆ, subfam. nov.

This group differs from typical Ophiacanthidæ chiefly in having the internal arm-plates so modified that the arms can be coiled in a vertical plane, like the *Astrophytons*, etc. The arm-spines are short, subequal, not very rough. The disk-scales may be thickly covered with cuticle and granules, or they may be naked. The oral papillæ are few, in a simple row. The thick cuticle sometimes covers the mouth shields and lower side of the arms.

The modifications of the ambulacral ossicles fits these species more perfectly for clinging closely to gorgonians, etc., by coiling the arms closely around the branches. But this power is also common to various species of *Ophiacantha*, in a lesser degree.

Ophiochondrella Ver., gen. nov. Type, *O. squamosus* (Lym.).

This differs from true *Ophiochondrus* in having the disk covered with naked scales, above and below; in having the under arm-plates

covered and concealed by thick cuticle ; in having the under arm-plates in contact; and in having two tentacle-scales.

The arm-spines are short, nearly equal. Radial shields naked, ovate, and separate.

Ophiochondrella squamosus (Lym.).

Ophiochondrus squamosus Lym., Bull. Mus. Comp. Zool., x, p. 275, pl. vii, figs. 108–110, 1883.

The disk-scales are thick, swollen, irregular. Arm-spines eight, tapered. Oral papillæ three, small, spaced. Tentacle-scales minute, rounded. West Indies, 250 fathoms, Blake Exped.

Ophiochondrus Lyman.

Bulletin Mus. Comp. Zool., i, p. 328, 1869; Voy. Challenger, p. 247, 1882. Type, *O. convolutus* Lyman.

The characters given to this genus by Mr. Lyman should be modified by adding that there are two or three nearly vertical plates at the base of the arm, supporting the ends of the radial shields, so that the edge of the disk is considerably raised above the arm, making a sharp angle with it. The radial shields are still more strongly supported by an elongated genital plate, running up each side of the genital slits and joining the radial shields.

Ophiochondrus crassispinus Lyman.

Ophiochondrus crassispinus Lyman, Bulletin Mus. Comp. Zool., vol. x, p. 275, 1883.

Several specimens from the Blake Exp., Station 232, 88 fath., off St. Vincent, were sent to the Yale Museum by Mr. Lyman under the name of *O. convolutus*, under which they are also evidently recorded in Mr. Lyman's lists of 1883.

These, on careful study, appear to belong to *O. crassispinus*, as defined and figured by Mr. Lyman. The latter was described from a single specimen, from 229 fath., Blake Exp.

They have three acute, conical, oral papillæ, exclusive of the odd terminal one. The oral shield is small, thick, pear-shaped, with an acute proximal angle ; arm-spines six or seven, short, nearly equal. A very small acute tentacle-scale is usually present in the larger specimens. Upper arm-plates on proximal part of arm, except two basals, are nearly quadrant-shaped with the outer edge convex and the lateral angles acute; distally they become more nearly triangular, with the sides a little convex.

The radial shields are large, elongated, separated by a band of small flat scales. Central part of disk and interradial spaces covered by very small, flat, naked scales. The arms are relatively stout, of moderate length, tapering rapidly.

O. convolutus L. is described as having the disk granulated ; oral papillæ four and squarish ; oral shield broader ; radial shields shorter and broader ; besides other differences. Possibly the two forms may be only variations of one species, but none of my specimens are intermediate.

One of the specimens from Station 232 was clinging closely to a group of Zoanthoid corals (*Epizoanthus*). The genus is evidently adapted to living clinging to *gorgonians* and similar organisms, for protection.

Family, **OPHIOSCOLICID** Ltk., 1869.

Ophiomyxidæ (*pars*) Ljung., 1866.
Ophioscolicinæ (sub-family) Ljung., 1871.

The upper side of the arms is covered with naked skin, beneath which the arm-bones can usually be seen. Under arm-plates and side arm-plates are present, though sometimes much degenerated. Arm-spines are moderately long, often rough or thorny, two to six in number. Tentacle-scale often wanting, but three or four are present in *Ophiambix*. Oral papillæ are usually numerous and form a continuous row, but sometimes they are few, and rarely lacking (in *Ophiobyrsa*). Tooth-papillæ usually lacking, rarely present as irregular spiniform papillæ. Teeth simple, spiniform.

Disk covered with a soft skin, which may contain minute scales and may bear granules or spinules. Radial shields small or rudimentary, sometimes lacking. Oral and adoral shields normal.

Internally the arm-bones of *Ophioscolex* are deeply grooved ventrally and dorsally and cut away laterally at the ends ; the mouth-frames are reduced and simple, but the peristomial plates are large and in three pieces.

In some of the other genera the arm-bones are more rudimentary. In *Ophiogeron* and *Ophiosciasma* they are entirely separated, along the median plane, in two elongated parts, curved towards each other. This is an embryonic character, illustrating the relatively low development of the skeleton in this family.

This family, as now known, seems to be more nearly allied to *Ophiacanthidæ* than to *Ophiomyxidæ*, with which it was formerly united.

Externally there are no tangible characters to distinguish this family from certain of the *Ophiacanthidæ*, except the lack of upper arm-plates, which are always present in the latter. But the internal structure, so far as studied, is peculiar.

The family, as here understood, includes the following described genera: *Ophioscolex*, *Ophiosciasma*, *Ophiogeron*, *Ophiobyrsa*, and *Ophiambix*.

Certain species that have been referred to some of these genera do not agree in structure with the typical species, and therefore I have established two new genera for their reception:

Ophiobyrsella, gen. nov. Type, *Ophiobyrsa serpens* Lyman.

Astrogeron, gen. nov. Type, *Ophiogeron supinus* Lyman.

Ophioscolex fragilis Ver., sp. nov.

Five slender arms. Oral shield small, narrow, pear-shaped, with an acute proximal angle. Adoral shields narrow, oblong, the inner end acute and touching. Oral papillæ six or seven, forming a row which is not regular in the middle; the two outer ones are larger than the others, tapered, acute; the four inner ones, which do not lie in just the same line, are small, slender, acute. Lower arm-plates hour-glass-shaped, narrow, longer than wide, truncated at the ends and closely joined, and apparently soldered with the side plates. Arm-spines three, slender, tapered, acute, nearly equal, about as long as a joint. Tentacle-pores large. No tentacle-scale. The disk is destroyed in my specimens.

Diameter of the disk-scar, 10^{mm}; length of arms, 22^{mm}.

Off Barbadoes, Station 293. Blake Exp., 82 fathoms.

Ophiobyrsella Ver., gen. nov. Type, *O. serpens* (Lym.).

Disk pentagonal, covered entirely by naked skin, which hides the oral and adoral shields and extends out over the upper and under sides of the arms and spines. Small spinules are situated over the region of the radial shields and along the margins of the disk, or over the whole disk. No tentacle-scales; tentacles large. Arm-spines three to five,—three in the type; rough, glassy. About five spiniform teeth. Oral papillæ form a regular lateral row, besides two or three tooth-papillæ at the tip of the jaw.

This genus is very near *Ophioscolex* in external characters.

True *Ophiobyrsa* (type, *O. rudis*) differs in having only one oral papilla, no teeth, and only a few spiniform tooth-papillæ; these parts being very much reduced.

Ophiobyrsella serpens (Lyman) is from the West Indies, in 69 fathoms.

Another species, *O. hystricis* (Lyman), with five slender and rather long spines, was dredged off the Shetland Islands, in 345 fathoms. (Bulletin Mus. Comp. Zool., vol. x, p. 272, Pl. viii, figs. 120–122, 1883.)

Astrogeron Ver., gen. nov. Type, *Ophiogeron supinus* Lym.

Disk and arms covered by a naked skin containing minute scales; beneath the skin are small rounded radial shields and very short genital plates and scales. Teeth small, spiniform; a cluster of spiniform tooth-papillæ at the end of the jaw, and a row of oral papillæ on the edge. Oral and adoral shields normal. No tentacle-scale. About two slender, glassy arm-spines covered by skin. Arm-bones divided longitudinally. The typical species of *Ophiogeron* has no oral papillæ, the jaw-plates being naked except for a few small spiniform teeth at the tip, but, otherwise, it agrees pretty closely with this.

Astrogeron supinus (Lym.) is from the West Indies, in 200 to 464 fathoms.*

Mr. Lyman has described several very remarkable genera, allied in some respects to *Ophioscolecidæ*, but presenting such peculiar structures that it does not seem reasonable to refer them to any of the described families. They should be considered as types of two distinct families, if the differences that separate families in other cases are taken as our criteria. In fact, they present greater diversities than can be found elsewhere in the entire group of regular Ophiuroids. Therefore I propose to classify them as follows:

Ophiomycetidæ, fam. nov.

Sub-family, *Ophiomycetinæ*, nov. Type, *Ophiomyces* Lyman.
Sub-family, *Ophiotholinæ*, nov. Type, *Ophiotholia* Lyman.

Ophiohelidæ, fam. nov. Type, *Ophiohelus* Lyman.

These groups will be described on subsequent pages.

Family, **OPHIOMYCETIDÆ**, nov.

Disk swollen, covered with scales, which may be either naked or spinulose. No radial shields. Teeth few. Two, three, or more apical tooth-papillæ. Oral papillæ numerous, the outer ones large,

* Bulletin Mus. Comp. Zool., vol. x, p. 270, Pl. vii, figs. 103 to 106, 1883.

flat, foliate or spatulate, recurved, in two or more divergent rows or clusters, partly on the adoral plates. The arms can be turned up vertically above the disk.

Sub-family, **Ophiomycetinæ**, nov.

Disk with small but distinct scales, usually spinulose. No grapel-shaped spinules on the arms. Arm-spines of the basal joints, and sometimes the lower ones on some of the joints beyond the disk, are flattened or spatulate ; others are long and slender. Tentacle-scales of basal joints flat, often multiple. Upper arm-plates small, separated. Side plates large, meeting above and below. Oral shield small. Adoral shield long, carrying many of the spatulate oral scales.

Internal mouth-frames slender; genital scales and plates broad, flat, and curved up over the base of the arm. Arm-bones well developed, but peculiar in form, and without a distal condyle. The arm can be turned up vertically above the disk.

Only four or five species are known. Two, *O. mirabilis* Lym. and *O. frutectosus* Lym., are West Indian. *O. spathifer* Lym. is from off Japan, in 565 fathoms, and *O. grandis* Lym. is from the South Atlantic, in 1000 fathoms.

Sub-family, **Ophiotholinæ**, nov.

No visible radial shields. Disk-scales delicate, spinulose. Arm-spines present on all joints, slender, about three ; associated with the spines, beyond several basal joints, are clusters of grapel-shaped spinules,* like those of *Ophiohelus*. A simple row of flat oral papillæ and tooth-papillæ surrounds the proximal ends of the jaws. Distally the oral papillæ and oral scales are very numerous, in several divergent rows, recurved, broad, flat, foliate or spatulate, much as in *Ophiomycetes*.

Several spiniform teeth. Tentacle-scales, on the basal joints, two or more, flat; on other joints, spiniform. The side arm-plates meet broadly below. Under arm-plates covered by cuticle.

This group is closely allied to *Ophiomycetinæ*, from which it differs mainly in having grapel-shaped spinules on the distal joints and in the more simple arm-spines.

*Mr. Lyman describes these as "pedicellariæ," but they are totally different from all forms of true pedicellariæ. They seem to me strictly homologous with the curved hooks and hooklets of *Astronyx* and allied genera, though much more complex in structure.

Only a single species is known : *Ophiotholia supplicans* Lym., taken off Juan Fernandez, in 1825 fathoms, Challenger Expedition.

Family, **OPHIOHELIDÆ**, nov.

No radial shields. Disk-scales very thin or rudimentary. Arm-bones divided into right and left plates. Oral papillæ spiniform, few, in a simple row. Teeth spiniform. Distal joints of arms bear rows of peculiar grapel-like or "parasol-shaped" spinules, in place of true spines. Only one genus is known.

Ophiohelus umbella Lym.

Mem. Boston Soc. Nat. Hist., 1880, pl. i, figs. 5–10 and 16.

This, the type-species, was taken off Barbadoes, in 82 fathoms.

O. pellucidus Lym.

Op. cit., pl. i, figs. 11–15, 1880.

This species was taken off the Fiji Islands, in 1350 fathoms, Challenger Expedition.

Family, **OPHIOMYXIDÆ** Ljung. (restr.), 1866.

Ophioscolecidæ (*pars*) Lutk., 1869.
Ophiomyxinæ (sub-family) Ljung., 1871.
Ophiomyxidæ Carus, Faunæ Medit., p. 96, 1884. Verrill, Oph. Bahama Exped., p. 65, 1899.

Disk and arms covered with thick cuticle, and usually with only a row of marginal disk-scales, and a few scattered ones imbedded in the cuticle, but visible only when dried. Radial shields small, usually with a proximal series of small supplementary scales.

Teeth and oral papillæ stout, flat, with the end serrated. No tooth-papillæ. True tentacle-scales generally absent. Under arm-plates small. Side arm-plates sub-ventral, bearing several rough divergent spines. Upper arm-plates rudimentary or lacking ; when present, composed of small pieces. Two large, triangular, peristomial plates on each mouth-angle.

Arm-bones peculiar, belonging to the modified "hour-glass-shaped" type, with well-formed condyles on both ends.

Ophiomyxa and *Ophiodera* are the only genera described. The second genus has the following characters :

Ophiodera Verrill, Oph. Bahama Exped., p. 67, 1899. Type, *O. serpentaria* (Lym.).

Marginal disk-scales are rudimentary and concealed by thick cuticle ; the disk-scales proximal to the radial shields are lacking. No upper arm-plates. Side arm-plates may be soldered to the under arm-plates. They are not continued upward by a row of small plates. Three or four arm-spines enclosed in cuticle; the inner one is smaller and may serve as a tentacle-scale; it is sometimes forked distally. Teeth and tooth-papillæ serrate, nearly as in *Ophiomyxa*, but with finer denticles.

Ophiodera Stimpsoni Verrill.

? Ophioscolex Stimpsoni Lyman, Illust. Cat. Mus. Comp. Zool., viii, p. 23, pl. i, figs. 11-15, 1875.

Ophiodera stimpsoni Ver., Oph. Bahama Exped., p. 67, pl. ii, figs. 4, 4*a*, 1899.

Plate XLII. Figures 2, 2*a*, 2*b*, 2*c*.

Arms very long and slender. Disk five-lobed, the lobes extending out a little on the base of the arms. Teeth three or four; upper one stout, spiniform, the others thicker, subtruncate.

Whole upper surface of disk and arms and lower surface of disk are covered with thin naked cuticle, wrinkled when dry, containing imbedded, scattered, microscopic scales on the disk, and a row of irregular small, marginal scales. Sometimes there are a few small, irregular granules along the margin and on the under side of the disk, and also on the bases of the arms. Radial shields very small or rudimentary, concealed by cuticle.

Diameter of disk 7^{mm}; length of arms about 45^{mm}.

West Indies, 60 to 240 fathoms.

Oral papillæ about five, partly slender, subspiniform, rough at tip, irregularly crowded in a row, nearly equal in length, but some are flattened and obtuse at tip. Sometimes there is also a somewhat stouter tooth-papilla. Within mouth-slits, on each side, there are two (sometimes only one) slender papillæ between the two oral tentacle-pores.

Genital slits wide and open near the oral shields, but narrow distally and not extending to the edge of the disk, bordered by narrow, naked scales.

Tentacle-pores are small and round. In some specimens there is a small, slender, spiniform tentacle-scale, which is often deeply forked, or even double, and in alcohol is covered with a sheath of cuticle ; it stands nearly in line with the other spines, beside the

tentacle-pore. It is often reduced to a minute spinule, and is frequently absent.

Arm-spines three or four, divaricate, small, nearly equal, sharp, roughly serrulate and glassy, more or less covered by cuticle when in alcohol.

The internal arm-plates show as transversely rhombic plates separated by wider intervals.

Family, **HEMIEURYALIDÆ** Ver., Oph. Bahama Exped., p. 70, 1899.

In this family are included several genera of true Ophiuræ, which very much resemble, in form and habits, the simple-armed Euryalæ or Astrophytons. Like the latter, they coil their arms closely around the branches of gorgonian corals on which they dwell.

The disk is pentagonal and covered with thick plates or tubercles, which may be conical. The radial shields are large and prominent.

Upper arm-plates may be entire and accompanied by supplementary plates, or they may be replaced by a mosaic of small plates. They are thick or tubercular.

Under arm-plates well formed. Side-plates separated by extra plates. Oral and adoral shields normal. Spines few, short and stumpy. A row of oral papillæ. Teeth, but no definite cluster of tooth-papillæ.

Genital pores small, situated near together at the outer end of the oral shield. Arm-bones have special forms approaching those of the *Astrophytons.* Mouth-frames strongly ossified.

The genera belonging to this family are *Hemieuryale*, *Ophioplus*, and *Sigsbeia.*

Hemieuryale pustulata Von Martens.

Hemieuryale pustulata Von Mart., Monatsb. Konig. Akad. Berl., p. 484, 1867; Ljung., Dr. Goes., Oph., Ofv. Kong. Akad., p. 617; Lyman, Ann. Sci. Nat., xvi, Art. 4, p. 5; Bull. Mus. Comp. Zool., iii, 10, p. 268, pl. v, figs. 8–11; op. cit., x, p. 277; Report Voy. Challenger, Zool. Ophiuroidea, v, p. 249, pl. xliii, fig. 7–10 (anatomy), 1882.

Ophiura cuspidifera (?) Lamk., Hist. Anim. s. Vert., iii, p. 226, 2d ed., 1840; Encyclop. Meth., pl. cxxii, figs. 5–8.

Disk small, thick, swollen, pentagonal, with a swelling opposite the base of each arm when dried; whole surface, except radial shields, covered with larger and smaller thick scales and verrucæ. The central primary scale is round and rough like the radial shields, but not swollen. Five primary rounded radial scales, which are

larger than the rest, are strongly convex or pustular, and often white. Five somewhat smaller convex interradials may usually be distinguished by their size; the other plates and scales are of various sizes, the larger ones convex or somewhat verruciform, while the small ones are nearly flat. A radial band of small scales extends continuously between the radial shields and out over the upper side of the arms, becoming flat, angular, and closely crowded on the arms, so as to form a fine mosaic.

Radial shields long-ovate, widely separated; the surface is evenly covered with fine hemispherical elevations; the side arm-plates are ornamented in a similar manner. Along each side of the arms, above, there is a row of elevated, verruciform or almost hemispherical plates, alternating with the side arm-plates; part of these are usually pure white, alternating with others that are deep brown. Under arm-plates well developed, trapezoidal, with acute outer angles, and with a rather deep median emargination or notch in the distal edge, except on six or seven basal ones; close to the base they are larger than broad, but farther out they become broader than long. Arm-spines generally two, small, short, nearly equal, obtuse, becoming longer and more slender distally. Tentacle-scale rather large, ovate, obtuse. Oral shield large, often white, somewhat "spade-shaped" with the outer end and sides, evenly rounded, the inner edges concave, the median and inner lateral angles acute; they vary considerably in different specimens. Adoral shields swollen, somewhat crescent-shaped or pear-seed-shaped, with the acute inner ends touching. Oral papillæ about five, angular, crowded in a close series, the outer ones larger. Genital openings small, like an angular pore, between two angular plates, at the outer edge of the oral shields.

Color reddish or yellowish brown, spotted and blotched with clear white in various ways, so as to closely imitate the color and appearance of certain species of *Gorgonella* to which it habitually clings. Usually there are rows of white verruciform plates along the arms on the upper side, resembling in size and color the verrucæ of the coral, which has a brown ground-color, like that of the *Hemieuryale*. Part of the tubercular plates of the disk, part of the oral shields, part of the spines, and part of the side arm-plates are also usually white.

Common in water of moderate depth throughout the West Indies wherever the *Gorgonella* lives. Specimens from off Barbadoes have been in the Yale Museum many years. Taken by the Blake Expedition in 74 to 180 fathoms.

Ophioplus Verrill, Ophiur. Bahama Exped., p. 70, 1899.

Type, *Hemieuryale tuberculosa* Lyman.

Disk small, pentagonal, thick, covered with small, thickened or tubercular scales. Radial shields large, naked, separated. Oral shields and adoral shields well developed and naked. Oral papillæ in regular series. No tooth-papillæ. Under arm-plates rather large. Upper arm-plates entire, swollen and well formed, separated by a transverse row of small, tubercle-like plates. Side arm-plates prominent, separated above by a supplementary lateral plate. Arm-spines short, two or three in a row. Tentacle-scale single. A pair of small, round genital pores under the outer end of the oral shields.

This genus differs decidedly from *Hemieuryale*, to which it is allied, in having distinct and well formed dorsal arm-plates. It is also closely allied to *Sigsbeia*. In fact, it stands between these two genera in several characters.

Ophioplus tuberculosus (Lym.) Ver.

Hemieuryale tuberculosa Lyman, Bull. Mus. Comp. Zool., vol. x, p. 276, pl. viii, figs. 120–127, 1883.

Ophiomusium (?) Nutting, Narrative, p. 78.

Ophioplus tuberculosus Ver., Ophiur. Bahama Exped., p. 71, pl. i, figures 1–1*b*, 1899 (description).

Plate XLIII. Figures 6–6*d*.

Color deep brown, variously spotted with whitish, imitating the colors of *Gorgonella* to which it clings.

Usually many of the more prominent verruciform plates of the upper side of the arms and disk are white; under arm-plates dark brown.

Taken by the Blake Expedition in 96 and 115 fathoms; Bahama Expedition, Station 15 and 16, off Havana, 200 fathoms.

Sigsbeia murrhina Lyman.

Sigsbeia murrhina Lyman, Bull. Mus. Comp. Zool., v, 9, p. 234, 1878, pl. iii, figs. 55, 58; op. cit., x, p. 277; Lyman, Report Voy. Challenger, Zool., Ophiuroidea, v, p. 250, pl. xliii, figs. 4–6, 1882, anatomy; Three Cruises of the Blake, ii, p. 114, fig. 399, 1888. Nutting, Narrative, p. 79. Verrill, Oph. Bahama Exp., pp. 72, 73, pl. ii, figs. 1, 1*a*, 1899 (Young, description.)

Plate XLII. Figure 7.

This species clings to gorgonians, which it imitates by the form of its arms and the tuberculated surface of the disk, and probably also in color, when living. Our figure represents a young specimen, which differs considerably from the adult.

Family, **OPHIOBRACHIONTIDÆ** Verrill, nov.

Disk entirely covered with acute spinules and cuticle, without radial shields or ribs. Arms long, slender, serpentine, so covered with cuticle that the plates are hidden. Under arm-plates are present. Side arm-plates not prominent, bearing rows of small double hooks on all the joints, but no spines. Upper arm-plates rudimentary or lacking. Tooth-papillæ spiniform, in an apical cluster; a few similar mouth-papillæ.

The only species, *Ophiobrachion uncinatus* Lym., is from off Cuba, in 250 fathoms.

Order II, **EURYALÆ** Müll. and Trosch., 1842.

Euryalidæ Gray, Synop. Brit. Mus., p. 63, 1840.
Astrophytonidæ Norman, Ann. and Mag. Nat. Hist., xv, p. 104, 1865.
Phytastra Hæckel, Gen. Morph., ii, p. 67, 1866.
Astrophytidæ Lyman, Ljungman, and others.
Euryalæ Müll. and Troschel, Syst. Aster., p. 85, 1842. Ljung., Oph. Viv., p. 334, 1867. Carus, Fauna Medit., p. 97, 1884. Verrill, Ophiur. Bahama Exped., p. 73, 1899.
Cladophiuræ Bell, Proc. Zool. Soc. London, p. 180, 1892; Catal. Brit. Echinod., p. 26, 1892.
Euryalida of several authors.

Family, **EURYALIDÆ** (*pars*) Gray, 1840, restricted.

Astrophytidæ (*pars*) Lyman, and many other authors.

Arms more or less dichotomous. Disk covered with cuticle and granules, and having ten strong radial ridges.

Teeth strong and large, in a single vertical row, as in Ophiuræ. Tooth-papillæ, few or none. Oral papillæ minute, papilliform, or lacking. Adoral shields and jaw-plates large, well formed. Oral shields rudimentary.

Under arm-plates simple; they extend the whole length of the arm. Side arm-plates small, appressed proximally, but prominent or erect distally, where they bear double claw-like hooks and thorny spinules; toward the base of the arms they bear few, small, rough, simple spines or tentacle-scales. Two rows of small plates, extending up from the side-plates, form transverse ridges, around the arms. Large spines, along the upper side of the arm, are borne by some of these plates. Dorsal arm-plates are represented only by small detached pieces.

In having a regular row of teeth and simple normal under arm-plates this group resembles ordinary *Ophiuræ* and differs widely from the *Gorgonocephalidæ*.

Subfamily, **Euryalinæ**, nov.

Arms wide at base, many times dichotomous, with short internodes, bearing two dorsal rows of spines. Disk large, with ten granulated radial ridges. Radial shields long, narrow, composed of only one piece, covered, like the rest of the disk, with cuticle. Interbrachial areas, below, covered with strong united plates.

The type, *Euryale aspera* Lam., is from the East Indies and China Sea.

Subfamily, **Trichastrinæ** Ljung., 1872.

Disk relatively small, but thick, with ten stout radial ribs. Arms angular, stout and high at base, divided only distally into a small number of forks. Tentacle-scales short and stout, about three in a row.

Oral shield well developed.

The type, *Trichaster palmiferus* (Lam.), is from the East Indies.

The arms have two dorsal rows of short, stout, obtuse, conical spines; they generally occur on alternate ridges.

The teeth are very large and thick, with truncate ends. Usually there is a single, large, conical tooth-papilla at the apex of the jaw. Oral papillæ small, papilliform, in two or more rows. The disk and arms, above and below, are rather coarsely granulated.

Family, **GORGONOCEPHALIDÆ** Verrill.

Gorgonocephalinæ (*pars*) Ljung., 1867. Bell, Catal. Brit. Echinod., p. 27, 1892.

Gorgonocephalidæ Verrill (restr.), Ophiur. Bahama Exped., Bull. Univ. of Iowa, v, p. 83, 1899.

Arms divided dichotomously into numerous branches. Disk swollen, with ten prominent radial ribs, covered with cuticle, which may bear granules or scattered spinules, or it may be more or less naked. Radial shields, each composed of several united plates.

The entire surface of the arms and disk above and below is covered with cuticle which is usually granulated, so that the plates are hidden.

Under arm-plates mostly rudimentary, consisting of two or more small pieces, sometimes absent. Side arm-plates are united below

and cover most of the under side of the arms. They bear a row of few, small, rough spines or spiniform tentacle-scales, which are usually hook-like distally. Two or more rows of small plates run up from each of the side plates and form transverse ridges around the arms, covered with granules; these usually bear rows of small glassy hooks. The dorsal arm-plates are rudimentary or wanting.

Teeth and tooth-papillæ numerous, spiniform. Oral papillæ, when present, small, conical or papilliform. Adoral shields well-developed, but usually concealed by cuticle, sometimes broken into several plates. Oral shields rudimentary or wanting. Sometimes there are five small madreporic plates, but usually only one.

The three generic names: *Gorgonocephalus* Leach, 1815; *Euryale* Lamarck, 1816; and *Astrophyton* Agassiz, 1835, were, as originally used and intended, exact synonyms. As now employed, they only date back to Lyman's paper on the Challenger Ophiuroidea, 1878.

That he rightly divided these forms into three distinct genera cannot be doubted, and he doubtless had the right to apply the three names, as he did, to the respective groups, though it might, perhaps, have saved some confusion of nomenclature if he had given new names to two of the genera.

It is certainly useless to go back to Linck, 1733, as the prior authority for *Astrophyton*, for he was not a binomial writer.

For the same reason it is useless to try to restore the ancient pseudospecific names given by Linck and even by Seba (e. g. *costosum*), when later and determinable specific names have been given by binomial writers.

Gorgonocephalus Leach (Zool. Miscell., 1815) is the oldest of the three names under the binomial system. Leach gave a short diagnosis of the genus, and stated that he separated it from *Ophiura* on account of its branched arms. He mentions no special type, but refers to the fact that most writers, following Linné, had referred all the species to "*Asterias caput-medusæ*."

As the latter was primarily based on a species of northern Europe, Lyman's selection of the northern genus to bear this generic name was fully justified.

As for the other two names, since they were synonyms he could have applied each of them to either of the remaining groups with equal propriety, for each name had been used for all the known species.

There certainly is no good reason why Mr. Lyman's usage should not be followed, so far as these genera are concerned.

This family, as here defined, includes only two described genera : *Gorgonocephalus* and *Astrophyton*. To these should be added a third, to include *Euryale verrucosum* Lam., which differs much from both the others. For this I propose the name *Astrocladus*.

Astrocladus Verrill, gen. nov.

Resembles *Gorgonocephalus* in form, but differs in having no pavement of plates on the margins and interradial areas ; in the absence of under arm-plates ; in having no minute hooks on the arm-ridges ; in having no spines or tentacle-scales on the basal points ; in having the side arm-plates more degenerate, and not covering all of the under side of the arms, leaving spaces of naked cuticle between them. The arms have very numerous forks.

The type, *A. verrucosus* (Lam.), has rather large, rounded or verruciform tubercles, arranged in two irregular rows along the upper side of the arms and on the radial ridges of the disk.

There are usually three short, stout, obtuse tentacle-scales, thorny at the tips.

The tooth-papillæ and teeth are very numerous, elongated, spiniform. The oral papillæ form two or more rows; the larger ones are cylindrical or spiniform, the smaller ones conical.

The whole surface of the arms and disk, above and below, is covered with fine and close granules. The annulations of the arms are not very prominent.

The forkings of the arms are very numerous, with short internodes. The arms are stout at the base.

The adoral and oral shields are represented by a group of irregular plates. The interradial areas below are covered with thin granulated cuticle, without plates.

It has been recorded from the Cape of Good Hope, etc. A specimen in the Yale Museum is labeled as from Japan, but this locality may possibly be erroneous.

Family, **ASTROCHELIDÆ** Verrill.

Astrochelidæ Verrill, Ophiur. Bahama Exped., p. 79, 1899.

Arms simple or with a few distal forks, granulated, and also annulated with raised ridges. Disk with five or ten radial ridges, its surface granulated or spinulose.

The genital openings are short, situated toward the margin of the disk, or not close to the inner angles.

Under arm-plates rudimentary or lacking. Side arm-plates cover most of the under surface, but are hidden by cuticle and granules.

They bear a short row of small rough spines or tentacle-scales; above them are double vertical rows of small plates, forming raised ridges and bearing granules and also rows of minute glassy hooks, on the sides and top of the arms. These sometimes extend on the radial ridges of the disk.

Teeth and tooth-papillæ numerous, spiniform; the latter form an apical cluster. Oral papillæ similar in form, sometimes lacking. The teeth may form double vertical rows.

This family includes *Astrochele*, *Astrogomphus*, *Astroporpa*, and *Astrotoma* all with simple arms, and *Astrocnida* with the arms forked near the ends.

Family, **ASTROSCHEMIDÆ** Verrill.

Astroschemidæ Verrill, Ophiur. Bahama Exped., v, p. 76, 1899.

Arms simple, long, slender, coiled. Disk five-lobed, with ten radial ribs; naked or granulated. Radial shields narrow, usually elongated. Under arm-plates small. Upper arm-plates poorly developed, often wanting, sometimes represented by two or more pieces, covered by naked skin or granulated. Side arm-plates relatively large, covering a large part of the lower side of the arm, and usually bearing two elongated spines or tentacle-scales.

Teeth are large, stout, several in a vertical row. Oral papillæ are small or wanting.

Oral and adoral plates, regularly formed, but covered by cuticle. Genital slits short, situated near the outer margin of the disk.

Internal mouth-frames strong, well developed, but without wing-like processes.

This family includes *Astroschema*, *Astrocreas*, and *Ophiocreas*.

Family, **ASTRONYCIDÆ** Verrill.

Astronycina (*pars*) Ljung., Oph. Viv., 1867. Bell, Cat. Brit. Echin., p. 27, 1892.

Astronycidæ Verrill, Ophiur. Bahama Exped., Bull. Univ. Iowa, v, p. 74, 1899.

Arms undivided, long, slender, coiled, not annulated nor granulated. Disk with ten narrow radial ridges formed by long narrow radial shields, covered with thin, smooth scales or naked skin.

Upper and under arm-plates rudimentary or absent. Side arm-plates cover most of the lower side of the arm and project laterally, bearing two, three, or more spines or tentacle-scales, which may be either simple or hook-like. The genital slits are short, near together in a depression near the oral shields.

Teeth stout, well formed, in a single row. Tooth-papillæ one or two, conical, sometimes absent. Oral papillæ small, like conical granules, placed above the margins of the jaw. Oral and adoral plates regularly formed.

Astronyx was the only described genus of this family, till recently, when I added to it a new genus, *Astrodia* (type, *A. tenuispina* Ver.), from deep water off the U. S. coast.

Astronyx Lymani Verrill.

Astronyx Loveni Lym., Bull. Mus. Comp. Zool., vol. x, p. 282, pl. viii, figs. 136–138, young (*non* Müll. and Troschel).

Astronyx Lymani Verrill, Ophiur. Bahama Exped., v, p. 74, pl. viii, figs. 4–4*e*, 1899.

Plate XLII. Figures 6–6*c*.

Arms five, long, slender, coiled. Disk pentagonal with incurved margins, and ten high, long radial shields, which are widely separated, curved outward in the middle and somewhat sinuous distally, the outer end a little clavate or knobbed ; the edge is serrulate with small scales. The radial shields and disk are covered with a thin, smooth skin which extends out on the arms, above and below. Interbrachial region below, in the dry specimen, concave or sunken, with the two short but wide genital openings close together, near the inner angles.

Astrodia Verrill. Type, *Astronyx* (?) *tenuispina* Ver.

Astrodia Verrill, Ophiur. Bahama Exped., p. 74, 1899.

Disk small; arms very long, slender, much coiled. Upper and under surfaces of the disk and arms covered with thin, delicate, closely imbricated scales, without granules.

Under arm-plates not distinct, except on one or two basal joints.

Arm-spines three, except on a few basal joints, rather long, tapered, simple, thorny at the tip, but not becoming hooked, even on the distal part of the arms.

Teeth stout, obtuse, the lowest not differing much from the rest. No tooth-papillæ. A row of small granule-like oral papillæ. Oral and adoral shields well developed.

The type-species lives clinging, by its coiled arms, to a species of slender, pennatulid coral (*Scleroptilum gracile* V.), in 1362 to 2033 fathoms, off the United States East Coast. (See Amer. Journ. Sci., vol. xxviii, p. 219, 1885; and Annual Rep. U. S. Fish. Com. for 1883, p. 550 (as *Hemieuryale tenuispina*).